SMALL HYDRO PREFEASIBILITY STUDY FOR WHITESAND CONTROL DAM NEAR SOUTHEND, SASK.

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FOR WHITESAND CONTROL DAM

NEAR SOUTHEND, SASK.

Prepared for:

Saskatchewan Power Corporation

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With contributions from:

Remote Community Demonstration Program
of Energy, Mines and Resources Canada

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EXECUTIVE SUMMARY

The main aspects of this study can be summarized as follows:

1. The community of Southend is typical of many northern isolated communities. Basic services such as power, health facilities and police are provided. The economic base of the community consists of hunting, fishing, trapping and tourism. Apart from the continuing construction of new facilities within the community, the only proposed economic development in the geographic area that would have provided the community with both employment and commercial prospects is a graphite mine at Deep Bay. This mine has been shelved at this time due to a soft market and will probably not be reconsidered until the mid-1990's. Factors that could affect this decision would be an increase in demand for graphite and/or a reduction in the cost of electricity and hence the cost of production.

   A proposed gold mine at Waddy Lake is unlikely to have any effect on the community of Southend. This mine, which will probably be commissioned in 1986, could however, be provided with electricity from a hydro-electric development at Whitesand Dam.

2. Three load forecasts have been prepared for Southend for the period 1984 to 1995. The first load forecast considers only the normal electric load and represents the lower limit to the load growth. The second considers the normal electric load and the increase in load caused by a total conversion from heating oil, propane and wood to an equivalent consumption of electricity: this represents the upper limit to the load growth. The third represents the most probable load growth and considers the normal electric load together with the increase in load due to the conversion of oil and oil/wood furnaces to a hybrid heating system.

   The third or most probable case results in projected energy requirements and peak load (at the generator) for the communities of Southend and Brabant Lake of 6,233 MWhr and 2,257 kW respectively by 1995. These projections exclude any mining development. The projected energy requirements and peak load are 4,000 MWhr and 750 kW for the proposed gold mine in the Star Lake/Waddy Lake area.

Due to the absence of information regarding the proposed graphite mine at Deep Bay, it was not possible to assess its impact on the community of Southend. However, if the mine proceeds, it will have a peak load of about 3,000 kW. This load will be served by a separate additional development to be constructed some time after the initial installation.

We understand that the existing diesel generating station is in need of a major upgrading and it has therefore been assumed that the proposed hydro-electric installation would be commissioned as quickly as possible to replace the existing plant. The load forecast indicates that a 750 kW unit would meet the requirements of the communities of Southend and Brabant Lake for two years at which time another 750 kW unit will become necessary. Further, the load growth indicates that a third unit will be required before 1995. This unit has not been included in the economic analysis because its date of commissioning is highly dependent on the rate of acceptance of the hybrid heating system.

A 750 kW unit will be required to serve the proposed gold mine in the Star Lake/Waddy Lake area. The current schedule for the mine indicates that this unit should be part of the initial installation.

Cost estimates were therefore prepared for an initial installation consisting of either a single 750 kW unit or two 750 kW units, as well as for a separate later 3 X 1000 kW development to serve the proposed graphite mine.

3. Layouts for the proposed initial 2 X 750 MW hydro-electric development have been prepared and are presented as Figures 4.6 and 4.7. This development is located on the centre island between the two dam sluiceways. This location could ultimately accommodate up to four 750 kW units. The proposed 3 X 1000 kW power plant to supply power to the mine at Deep Bay is a separate installation as shown on Figures 4.8 and 4.9. This development would be built at some future date after the commissioning of the initial installation. Both arrangements have been designed to maximize off-site fabrication and minimize site construction. They comprise a syphon intake, steel penstock and powerhouse. The powerhouses have steel framed substructures.

The net minimum head available at this site is approximately 6.8 m. The turbine discharge capacity at this head is approximately 26 cms for the initial 2 x 750 MW installation and 52 cms for the 3 x 1000 kW addition.

The most economical turbine, of those considered, is the Turbogen semi-Kaplan turbine by Waterwheel Erectors. This turbine would also be the easiest to salvage should this become necessary. Layouts for powerhouses using this turbine are presented as Figures 4.4 and 4.5. The proposed schedule presented on Figure 5.1 is also based on this turbine. Because the delivery lead time for this unit is considerably shorter than for the Kaplan and Ossberger turbines also considered, the initial development could be commissioned in mid-1986.

4. The only alternative hydro-electric site considered for evaluation was Otter Rapids on the Churchill River. A development at this site would require the construction of a dam. The cost of a hydro-electric development at this site is estimated to be $18,970,000 for an initial 2 X 750 kW installation and $10,020,000 for the addition of 3 X 1000 kW at a later date. The costs are in 1984 dollars and in accordance with the terms of reference do not include the cost of transmission lines.

An initial 2 X 750 kW development at Whitesand Dam is estimated to cost $7,560,000 and a separate 3 X 1000 kW development to be constructed later is estimated to cost $10,920,000. These costs are in 1984 dollars and assume the materials and equipment will be transported to site over a winter road to be constructed between Southend and Whitesand Dam. The cost of clearing and constructing the winter road is included in the capital cost of the initial installation only. It is assumed that the road would be maintained and available for use should the 3 X 1000 kW addition be built. On the basis of capital cost, this site is the most economical. The cost of a single 750 kW unit at this site is estimated to be $5,440,000; this installation is assumed to have an intake and penstock sized for two units.

For the initial 2 X 750 kW development with one unit serving the communities of Brabant Lake and Southend and one serving the proposed gold mine in the Star Lake/Waddy Lake area, the unit cost of supplying energy is estimated to be 13.4 cents per kWhr at an assumed effective discount rate of 6%. This value is in 1984 dollars and is based on a 35 year life for the development. It includes the installation of a second 750 kW unit two years after the initial development has been commissioned. Annual operating and maintenance costs have been included. The weighted average cost of supplying electrical energy and heat by diesel units and oil heaters is estimated to be 17.1 cents per kWhr in 1984 dollars.

For a later separate 3 X 1000 kW development fully dedicated to supply the proposed graphite mine at Deep Bay, the unit cost is estimated to be 6.7 cents per kWhr at an assumed effective discount rate of 6%. This value is in 1984 dollars and is based on a 35 year life of the plant. Annual operating and maintenance costs have been included. Based on the existing diesel units at Southend, the cost of supplying energy by diesel generators is estimated to be 19.1 cents per kWhr in 1984 dollars.

5. RECOMMENDATIONS

Based on the findings of this study, we recommend that discussions be undertaken with the Saskatchewan Minerals Development Corporation to determine the impact of the unit cost of supplying power from Whitesand Dam on the proposed mines at Waddy Lake and Deep Bay.

We also recommend that, on the basis of unit costs, this project should proceed. A decision should be made very early in 1985 to enable the initial generating facilities to be on-line by mid-1986. This schedule would allow the gold mine at Waddy Lake to be served by the new hydro-electric development.

ÉTUDE PRÉLIMINAIRE DE FAISABILITÉ:

PETITE CENTRALE HYDRO-ÉLECTRIQUE AU BARRAGE DE WHITESAND

Près de Southend (Saskatchewan)

Résumé

La collectivité de Southend est un exemple type des nombreuses agglomérations isolées du Nord. Les services publics de base tels que l'électricité, les services de santé et de police y sont fournis. L'économie de la collectivité repose sur la chasse, la pêche, le piégeage et le tourisme. Mise à part la construction de nouvelles installations à l'intérieur de la collectivité, le seul projet de développement économique dans la région qui aurait pu offrir des possibilités d'emploi et des débouchés commerciaux concerne une mine de graphite située à la baie Deep. Le projet a été mis au rancart à cause des marchés déprimés; la mise en exploitation ne sera probablement pas considérée avant le milieu des années 90.

Une mine d'or qui est proposée au lac Waddy n'aura probablement aucun effet sur le hameau de Southend. La mine, qui sera probablement mise en exploitation en 1986, pourrait cependant s'alimenter en électricité à une centrale hydro-électrique au barrage de Whitesand, situé à quelque 12 km au sud-est de Southend.

Pour la période allant de 1984 à 1995, trois prévisions de la charge ont été préparées pour Southend. La première ne tient compte que de la charge électrique normale et représente la limite inférieure des hypothèses sur la croissance de la charge. La deuxième tient compte de la charge électrique normale et d'une augmentation entraînée par le remplacement total du chauffage au mazout, au propane et au bois par le chauffage électrique: ce scénario représente la limite supérieure de croissance de la charge. La troisième prévision correspond au scénario le plus probable d'augmentation de la charge: elle prend en compte la charge électrique normale plus un accroissement entraîné par le remplacement des calorifères à mazout et à mazout/bois par des systèmes de chauffage mixtes.

Dans le troisième cas, qui est aussi le plus vraisemblable, on estime les besoins en énergie et la charge de pointe (au groupe électrogène) pour les localités de Southend et de Branbant Lake à 6 233 MWh et 2 257 kW respectivement d'ici à 1995. Ces projections ne tiennent pas compte de la possibilité d'autres exploitations minières. Les besoins en énergie et la charge de pointe projetés pour la mine d'or de la région du lac Star/lac Waddy se chiffrent à 4 000 MWh et à 750 kW respectivement.

En raison du manque de renseignements relatifs à la mine proposée à la baie Deep, il n'a pas été possible d'évaluer l'effet que sa mise en exploitation aurait sur la collectivité de Southend. Cependant, si le projet se réalise, il représentera une charge de pointe d'environ 3 000 kW. Cette demande serait satisfaite par une installation distincte qui serait construite après la première.

Nous croyons savoir que la centrale au diesel actuellement en place a besoin d'une rénovation majeure, et c'est pourquoi nous supposons que la centrale hydro-électrique projetée serait mise en service le plus rapidement possible pour remplacer la centrale actuelle. D'après les prévisions de la charge, une unité de 750 kW satisferait les besoins des localités de Southend et de Brabant Lake pendant deux ans, après quoi il faudrait y adjoindre une seconde unité de 750 kW. En outre, si l'on en juge par la croissance de la charge, une troisième unité s'imposerait avant 1995. Cette dernière centrale n'a pas été incluse dans l'analyse économique étant donné que la date de sa mise en service dépend dans une large mesure de la popularité du système de chauffage hybride.

Il faudra une centrale de 750 kW pour alimenter la mine d'or proposée dans la région du lac Star/lac Waddy. D'après le calendrier de construction de cette mine, cette unité devrait faire partie de la première installation.

Des estimations de coût ont donc été dressées pour une première installation qui comprendrait soit une unité simple de 750 kW, soit 2 unités de 750 kW, de même que pour une autre installation de 3 unités de 1 000 kW qui serait construite ultérieurement et qui alimenterait la mine de graphite projetée.

On a dressé les plans généraux de la première centrale hydro-électrique constituée de deux unités de 750 kW. Cette installation se trouve sur l'Île centrale, entre les deux pertuis du barrage. Ce site pourrait accueillir jusqu'à 4 unités de 750 kW. La centrale de 3 X 1 000 kW qui alimenterait la mine de la baie Deep est une installation distincte. Elle serait construite ultérieurement, après la mise en service du premier ouvrage. Les deux installations ont été conçues de façon à minimiser les travaux de construction sur le site. Elles comprennent une prise d'eau en forme de siphon, une conduite forcée et la centrale comme telle, dotée d'une infrastructure à charpente en acier.

La hauteur de chute minimale nette disponible à cet endroit est d'environ 6,8 m. À cette hauteur, le débit aux turbines se chiffre à environ 26 cm/s dans le cas de la première installation de 2 X 750 kW et à 52 cm/s pour l'installation de 3 X 1 000 kW.

De toutes les turbines considérées, la plus économique serait la semi-Kaplan Turbogen de la Waterwheel Erectors. Cette turbine serait également la plus facile à récupérer, les cas échéant. Les figures 4.4 et 4.5 montrent les plans des centrales équipées de cette turbine. Le calendrier proposé à la figure 5.1 a également été établi en fonction de l'utilisation de cette turbine. Comme le délai de livraison de cette unité est beaucoup plus court que celui des turbines Kaplan et Ossberger, la première installation pourrait être mise en service au milieu de 1986.

Le seul site hydro-électrique étudié est celui des rapides Otter sur le fleuve Churchill. L'aménagement de ce site exigerait la construction d'un barrage. La construction d'une centrale hydro-électrique à ce deuxième site coûterait environ 18 970 000 $ pour la première installation de 2 X 750 kW et 10 020 000 $ de plus si l'on y ajoutait une autre installation de 3 X 1 000 kW. Les coûts sont exprimés en dollars de 1984 et ne tiennent pas compte du coût des lignes de transport d'électricité.

Une première installation de 2 X 750 kW au barrage de Whitesand coûterait une somme estimée à 7 560 000 $; l'adjonction ultérieure d'une installation de 3 X 1 000 kW coûterait 10 920 000 $. Ces coûts sont exprimés en dollars de 1984 et supposent que les matériaux et l'équipement seront transportés au chantier sur un chemin d'hiver qu'il faudrait construire entre Southend et le barrage de Whitesand. Le coût du défrichement et de la construction du chemin d'hiver est compris dans le coût d'équipement de la première installation seulement. On suppose que cette route serait par la suite conservée et utilisée pour la construction de l'addition de 3 x 1 000 kW. Si l'on s'en tient au coût d'équipement, ce site est le plus économique. On estime à 5 440 000 $ le coût d'une seule unité de 750 kW à cet endroit, en supposant toutefois que les dimensions de la prise d'eau et de la conduite forcée seraient prévues pour deux unités.

Pour la première installation constituée de 2 unités de 750 kW, dont une desservirait la population du lac Brabant et de Southend, et l'autre alimenterait la mine d'or proposée dans la région du lac Star/lac Waddy, le coût unitaire de l'énergie est estimé à 13,4 ¢/kWh, pour un taux d'actualisation réel présumé de 6 %. Ce coût est exprimé en dollars de 1984 et est calculé sur une durée de vie utile de 35 ans. Il tient compte de l'installation d'une seconde unité de 750 kW deux ans après la mise en service de la première. Les coûts annuels d'exploitation et d'entretien sont également inclus dans ce chiffre. Le coût moyen pondéré de l'électricité et de la chaleur fournies par des centrales à diesel et des calorifères à mazout est estimé à 17,1 ¢/kWh en dollars de 1984.

Dans le cas d'une installation séparée de 3 unités de 1 000 kWh qui serait construite ultérieurement et qui alimenterait exclusivement la mine de graphite dont la construction est proposée à la baie Deep, le coût unitaire est estimé à 6,7 cents le kWh pour un taux d'actualisation réel présumé de 6 %. Ce coût est exprimé en dollars de 1984 et est calculé sur une durée de vie utile de 35 ans; il comprend les coûts d'exploitation et d'entretien. Si l'on en juge par les centrales à diesel déjà en place à Southend, le coût de l'énergie fourni par des groupes électrogènes diesel est estimé à 19,1 ¢/kWh en dollars de 1984.

À la lumière des résultats de cette étude, l'expert-conseil recommande que des discussions soient engagées avec la Saskatchewan Minerals Development Corporations pour déterminer l'incidence que le coût unitaire de l'électricité produite par une centrale construite au barrage de Whitesand aurait sur les projets d'exploitation minière du lac Waddy et de la baie Deep.

L'expert-conseil recommande en outre de procéder à la réalisation du projet, compte tenu de ces coûts unitaires. Il faudrait prendre une décision à cet égard au tout début de 1985, pour faire en sorte que la première installation soit en service au milieu de 1986. Cet échéancier permettrait à la mine d'or du lac Waddy d'être alimentée par la nouvelle centrale hydro-électrique.

L'étude a été réalisée par Fennell, Cochrane, Lavalin pour la Saskatchewan Power Corporation à l'aide d'une contribution financière des Affaires indiennes et du Nord Canada et du Programme de démonstration dans les collectivités éloignées d'Énergie, Mines et Ressources Canada.

PART 1 INTRODUCTION

1.1 GENERAL

Whitesand Dam is situated in northern Saskatchewan. The coordinates are 615,000 m E and 6,233,000 m N, see Figure 1.1. The dam, built in 1942, controls the outflow from Reindeer Lake. The prime purpose of the releases through this structure is to provide a more stable flow regime at the Island Falls hydro-electric generating station on the Churchill River downstream.

The dam is approximately 12 km south-east of the community of Southend. Access to the site is either by float plane, or by road to Southend and then by boat. Saskatchewan Power Corporation, which owns the dam, has a permanent superintendent at the site.

The dam consists of two concrete sluiceway structures. The discharge through the dam is controlled by removing or replacing stoplogs. The Churchill River Power Company, which used to own the dam, also used the lake storage to supplement the winter flows on the Churchill River. This operation generally resulted in a lake elevation in April of about 336 m.

There are presently no hydro-electric generating facilities at this dam.

1.2 PERTINENT DATA

Below is the relevant data for Whitesand Dam. This data has been taken from reports and drawings and has not been verified in the field.

1.2.1 Reservoir

Full supply level = 336.68 m
Low supply level = 334.06 m *

*currently under review

Reservoir area = 5 690 km^2 at elevation 336.52 m

1.2.2 Control Structure

Control is by stoplogs. Stoplogs are removed using an electric-powered stoplog hoist mounted on rail tracks.

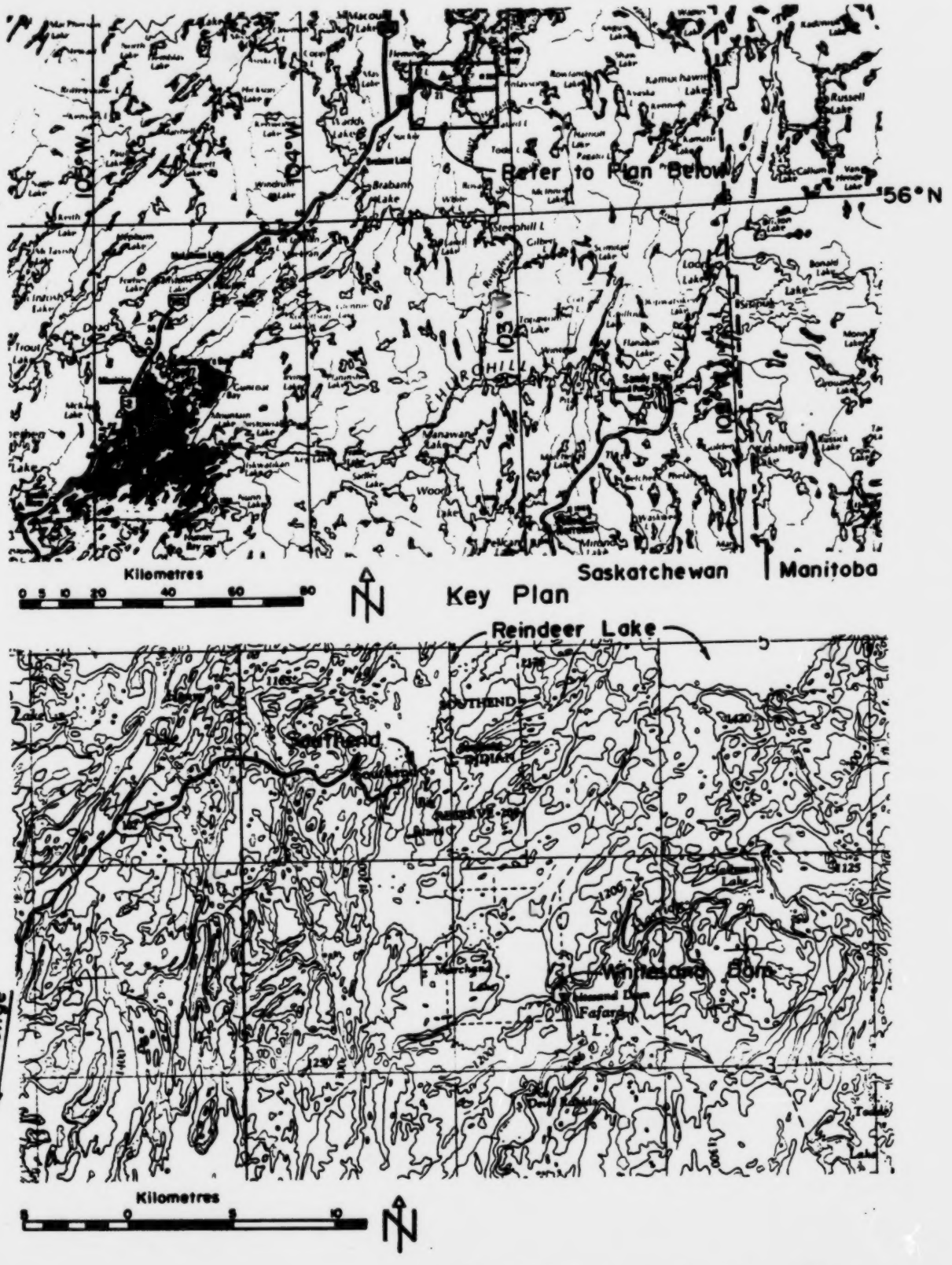


Figure 1·1 Location Plan

Left Sluiceway (North)

No. of openings	= 3
Width of openings	= 4.27 m
Sill elevation	= 327.22 m, 326.91 m and 326.76 m
Deck elevation	= 337.58 m

Right Sluiceway (South)

No. of openings	= 5
Width of openings	= 4.27 m
Sill elevation	= 326.61 m
Deck elevation	= 337.58 m

1.3 SCOPE OF WORK

The Scope of Work is contained in the terms of reference (see Appendix A). The objectives of the study can be summarized as follows:

- review of literature on recent small hydro innovations pertinent to this project;
- prepare a community profile for Southend by updating data available from a previous study;
- prepare a load forecast for the proposed development;
- select the optimum arrangement for a hydro-electric development at this site with an initial capacity of 500 kW and future expansion for mining loads of 1 MW and 3 MW;
- evaluate alternative hydro-electric sites;
- prepare cost estimates.

1.4 SMALL HYDRO TECHNOLOGY

In recent years, an abundance of technical papers and information guidelines or methodologies, or handbooks have been written on small hydro technology for presentation at seminars, workshops and conferences, for distribution by Government agencies or for publication in technical magazines. However, there is very little content within this literature which can be truly classified as innovative.

Some of the schemes proposed for the rehabilitation of old or abandoned dams and power stations may be viewed as innovative. Furthermore, some of the "home-designed" or "home-built" devices installed by individual developers may be so classified, but are not suitable for commercial application or service as envisaged for the Whitesand project.

Pre-fabricated or pre-assembled "package" units complete with control and protection devices are of interest but their use at Whitesand may be prohibited due to physical size limitations and shipping restrictions. The use of submersible pumps as turbine generators would be worthy of consideration except that designs for this type of equipment with synchronous generators is still in the research and development stage.

Although syphons have been used for centuries, this application for use as water intakes to penstocks supplying small hydro units which must operate under severe weather conditions can be ranked as innovative. A research and development unit installed by Ontario Hydro at Wasdell Falls provides a sound basis for considering this type of intake arrangement at Whitesand Dam.

PART 2 COMMUNITY PROFILE

2.1 GENERAL

The community of Southend is comprised of the Northern Hamlet of Southend, located on the west shore of Reindeer Lake, and an Indian community located on a nearby island. The Indian community is on Reserve No. 200 of the Peter Ballantyne Band. The two parts of the community are joined by a causeway and road constructed in 1979. A map of this community is shown on Figure 2.1. This map is based on aerial photographs taken in 1981 and does not show any subsequent development.

The following will provide a brief synopsis of the present community, an assessment of the population trend and the probable impact on the community of any proposed development in the general geographic area.

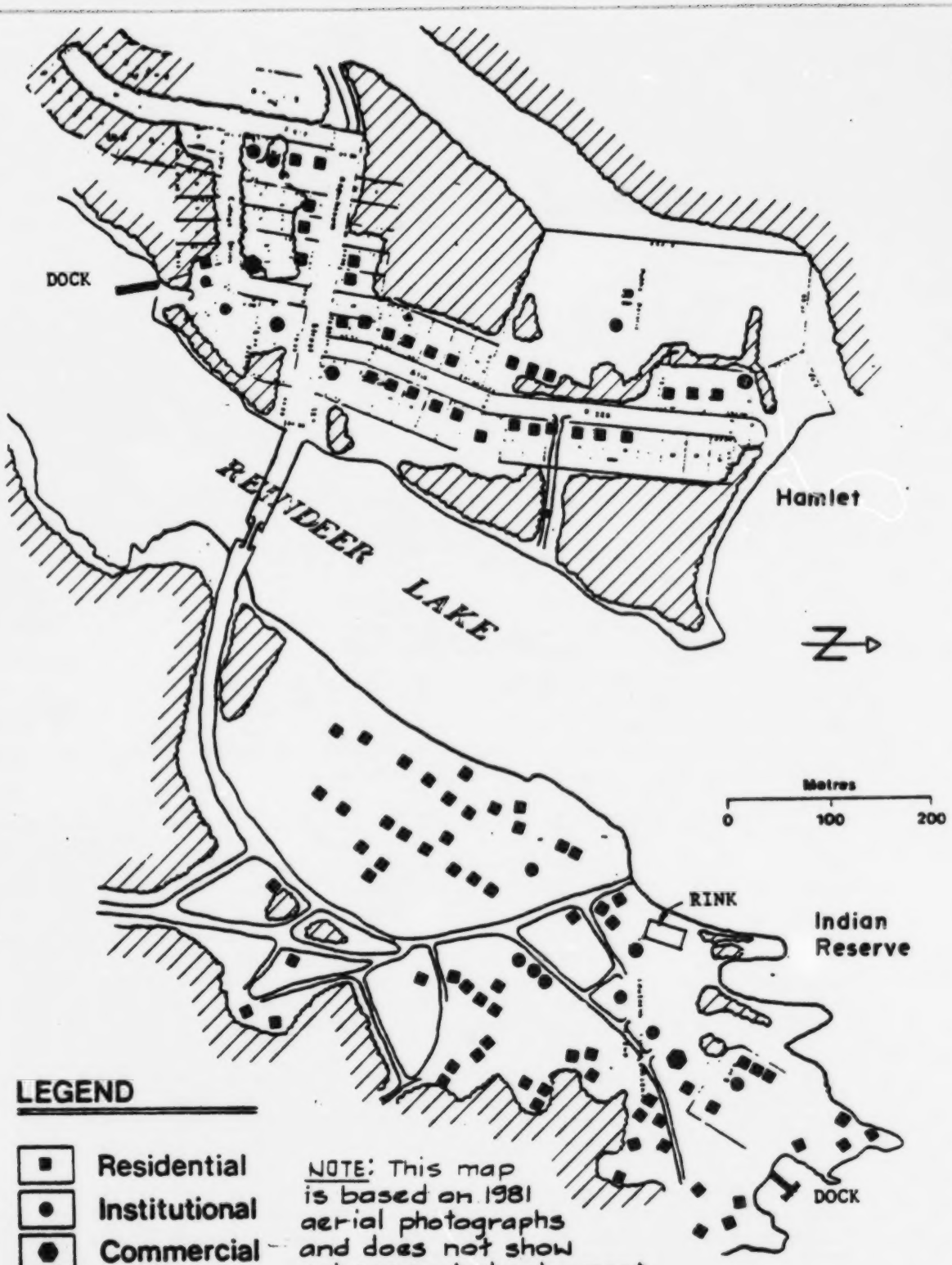
2.2 GOVERNMENT, UTILITIES AND SERVICES

The Province of Saskatchewan provides government services to the Hamlet while the Federal Department of Indian Affairs and Northern Development (DIAND) provides similar services to the Reserve. There are, however, many instances of shared government and commercial services such as police, electric power and transportation.

Electric power to the community is provided by two 250 kW and one 200 kW diesel generators. Since it is normal practice to provide one hundred percent standby for diesel installations, these units would be considered adequate for demands to a peak of 350 kW. These generators are operated by North Sask Electric. All houses except for three outlying residences, all government buildings and all commercial outlets are connected to the electric distribution system. Because diesel generators supply the power, some restrictions to the use of electric appliances do exist. For example, the use of 220 volt appliances such as electric ranges, clothes dryers and space heaters is not allowed.

Water is obtained from Reindeer Lake and local wells. A few buildings have water piped from wells but, in general, water is hauled to most buildings. Apart from water obtained from a well on the Reserve which is irregularly chlorinated, water is not treated before use.

Residences and buildings are either equipped with septic tanks or with outdoor toilets. The effluent is collected by private firms and taken to a sewage disposal pit. Solid waste is dumped into a landfill site located west of the Hamlet. Garbage is collected weekly from the Hamlet: no such service exists on the Reserve.



Taken from Reference 1

Figure 2·1
Community of Southend

Health care is provided on a full time basis at a federal health clinic by two nurses and a community health representative. A doctor visits the community once a week, a dentist twice a year and an optometrist once a year. Education facilities consist of two schools, one located in the Hamlet and one on the Reserve. Schooling is provided to Grade 7 only.

Access to Southend is by all weather road: Highway 102 south to La Ronge and Highway 105 north to Rabbit Lake. Apart from a mail taxi service from La Ronge twice a week, there is no regular bus or other transportation to the community, and access is either by private vehicle or plane or by charter.

2.3 ECONOMIC BASE

Following is a list of businesses presently located in the community:

a) SeSeep Air Services Ltd., a charter float plane company;

b) Hudson's Bay company, general store;

c) Nordic Lodge, outfitters;

d) Reindeer Lake Gulf Services, service station and bulk fuel; and

e) L.A.C. Sewage Disposal, hauling septic tank waste from the Hamlet (another operator serves the Reserve).

The general economic base for the community is comprised of fishing, hunting, trapping and tourism. As well as serving as guides, many members of the community earn incomes during the summer as cooks, housekeepers and dockhands for the five outfitters operating on Reindeer Lake. In addition, internal economic activity is created by the on-going construction projects at Southend.

A significant change to the present economic base is not likely in the short term. The development of graphite deposits some 12 km. away at Deep Bay would have a dramatic affect on the community, as Southend would probably absorb most of the accompanying demand for residential and commercial services. This mine which was under active consideration by the Saskatchewan Mineral Development Corporation has now been shelved (ref.1) due to the soft market and strong competition from China. Unless the graphite market changes dramatically or cheaper power becomes available, this mine will not be reconsidered until at least the mid-1990's.

References are listed at the end of the report.

The only other development in the region is another mine in the Star Lake/Waddy Lake area. This area has been under active exploration for many years and it is likely that Starrex will open a gold mine within the next 1 - 2 years (ref.2). An announcement will probably be made at the end of the summer drilling programme. Waddy Lake is situated close to Highway 102, approximately 55 km south of Southend. Although Southend is the closest community to this development, most if not all of the resulting residential and commercial services will be provided by La Ronge, some 180 km south of the mine. La Ronge is a much larger community with a well developed infrastructure and is served by a scheduled airline service.

2.4 POPULATION

The past and present population figures for the Hamlet and Reserve are presented in Table 2.1. These figures are considered to be reasonably accurate. The numbers for 1977, 1980 and 1982 have been taken from a report prepared by Underwood McLellan Ltd. (ref.3) for Energy, Mines and Resources Canada. These figures were taken from the 1980 Municipal Census, DIAND and other unspecified sources.

The population for mid-1984 for the Hamlet was obtained from the Hamlet Office (ref.4). Neither the Prince Albert office nor the branch office of DIAND could provide any figures for the Reserve more recent than 1980. The only other source of data are the registration statistics for the Saskatchewan Hospital Services Plan. This data was not used because it appears to be inflated by including people living outside Southend but in the general geographic area. Information received from the Peter Ballantyne Band indicates that approximately 400 band members had residences in Southend at the time of this study.

TABLE 2.1
POPULATION DATA FOR THE COMMUNITY OF SOUTHEND

	Population		
Year	Hamlet of Southend	Peter Ballantyne Band	Total
1977	198	325	523
1980	176	-	-
1982	178	350	528
1984	190	400	590

The total population of Southend for 1984 would therefore be about 590. This figure differs significantly from the population in 1982 of 635 reported by the Department of Northern Saskatchewan (ref.5). The difference is probably due to the statistics for the Saskatchewan Hospital Services Plan being included in the latter figure.

The ethnic mix of the population is reported (ref.6) to be 95% Metis in the Hamlet and 100% Cree for the Reserve.

From Table 2.1, the annual growth of the total population between 1977 and 1984 was an average of 1.74% per annum. Based on this increase, the total population will increase to 713 by the year 1995. This trend will probably not change prior to 1995 as a marked increase in population due to employment opportunities is not likely in the short term.

PART 3 LOAD FORECAST

3.1 GENERAL

The load forecast will determine not only the initial size but also the timing of extensions to the proposed hydro electric development to cater for increases in demand.

Two load forecasts have been prepared, the first and most complex, deals with the electric load of the Southend community. This forecast considers recent experiences in the accelerated load growth of communities, like Southend, that occur when restrictions placed upon the use of electricity have been removed. These restrictions, which prevent the use of 220 volt appliances such as electric ranges, clothes dryers and space heaters, are necessary where power is supplied by diesel generators. When preparing this load growth, the following factors were taken into consideration:

(a) The socioeconomic profile of the community;

(b) Net population growth and the growth in the number of electrical customers and consumption;

(c) The present economic base of the community;

(d) Proposed development plans for the area excluding any mining development; and

(e) Any energy related programmes that would affect the consumption of electricity.

The second forecast will take into account the foreseeable mining development and the effect of such development on the community of Southend.

Forecasting the load growth is a very subjective exercise. Recent experiences with forecasting on a provincial and regional basis have shown how much these figures can err. Attempting to assess the load growth for a small community is even more difficult and susceptible to error, as only a small change in economic base, such as the introduction of a new business, can have a significant impact on the electrical demand. For this reason, we only consider it meaningful to extend the forecast to 1995. This provides a realistic basis to economically evaluate the early unit installation.

3.2 COMMUNITY OF SOUTHEND

3.2.1 General

To assess the probable load growth for Southend, the historical trends for the consumption of electricity and number of customers have been broken down into the following categories;

- residential;
- commercial;
- government; and
- street lights.

These categories follow those used by North Sask Electric for the community. The reason for using these categories is to ensure that the projected consumption of electricity by customers in each of the groups remains realistic.

The projected electric load for heating purposes is presented separately. This load has a significant impact on the consumption of electricity and peak demand and is quite sensitive to factors such as energy related programmes, electricity rate structure, disposable income and social or cultural constraints.

The above forecasts will be combined to provide the probable load growth for the community. In addition, a maximum load growth is calculated assuming a total conversion from energy sources such as fuel oil, wood and propane to electricity. The latter will provide an upper limit to the load growth "curve".

The consumption of electricity and peak demand for Southend are presented in Table 3.1. This table covers the period of 1978 to 1983 inclusive and was taken from figures provided by North Sask Electric. These figures are net and do not include any estimated losses within the distribution system. As there are no wholesale customers, Table 3.1 represents the total consumption and demand for the community and inherently includes construction projects in the community.

3.2.2 Residential Consumption

The average increase in the number of residential customers between 1977 and 1983 was 4.3% per annum. Projecting this historical trend in the increase of residential customers or households and the projected increase in population of 1.74% indicates that the average number of people in each household will decrease from 6.25 in 1983 to 5.15 in 1995. Based on the age structure of the community in 1980 (ref.3),

this reduction in the size of the family unit is probably overstated. Using an average size of the family unit in 1995 of 5.75 will give a more reasonable average increase in the number of residential customers of 3.3% per annum. As there will probably be no factors affecting the disposable income, this increase is likely to continue unchanged.

Table 3.2 presents the projected residential load growth for the community.

TABLE 3.1
CONSUMPTION OF ELECTRICITY AND PEAK DEMAND
FOR SOUTHEND (1978 TO 1983)

	Year					
	1978	1979	1980	1981	1982	1983
Customers (no.)						
- residential	68	72	73	72	80	84
- commercial	6	6	5	5	11*	6
- government	16	20	17	20	21	23
- street lights		2	2	3	4	4
TOTAL	90	100	97	100	116	117
Consumption (kWhr)						
- residential	213 292	221 282	253 840	299 078	378 517	465 094
- commercial	92 701	90 595	98 123	120 427	135 003	160 376
- government	149 838	211 110	247 425	253 829	319 639	373 688
- street lights	4 118	4 594	7 731	7 732	9 420	9 604
TOTAL	459 949	527 581	607 119	681 066	842 579	1 008 762
Peak Load at Generators (kW)	159	163	167	188	221	242

*Includes temporary connections for school construction

Between 1977 and 1983, the consumption of electricity per household increased, on average, by 12% per annum. This increase in consumption will be due to the increased use of appliances and will probably continue at a decreasing rate until a consumption close to the average for Saskatchewan Power customers in northern communities is reached. From this point, the average consumption for northern customers should be used. The rate of increase was assumed to reduce from 12% between 1983 and 1984 in 1% steps to an increase of 1% between 1994 and 1995.

In the twelve months ending July 1984, about 4,200 North Sask Electric residential customers used an average of 10,572 kWhr of electricity. Of these customers, approximately 500 using space heaters had an average consumption of 19,883 kWhr. This would indicate that the average annual consumption of electricity for non-heat purposes is about 9,300 kWhr per customer. The provincial growth rate of 1.2% used by Saskatchewan Power was used to determine the average annual consumption for customers in Northern communities up to and including 1995.

TABLE 3.2
PROJECTED LOAD GROWTH FOR RESIDENTIAL CUSTOMERS

Year	Number of Customers	Consumption per Customer (kWhr)		Total Consumption (kWhr)
		Community of Southend	Ave. for North Sask Electric Customers	
1983	84	5 540	[illegible]	465 000
1984	87	6 200	[illegible]	539 000
1985	90	6 880	[illegible]	619 000
1986	93	7 570	[illegible]	704 000
1987	96	8 250	[illegible]	792 000
1988	99	8 910	[illegible]	882 000
1989	102	9 540	[illegible]	973 000
1990	105	[illegible]	10 070	1 057 000
1991	109	[illegible]	10 190	1 111 000
1992	113	[illegible]	10 310	1 165 000
1993	116	11 370	10 430	1 210 000
1994	120	11 600	10 560	1 267 000
1995	124	[illegible]	10 620	1 317 000

3.2.3 Commercial, Government and Street Light Consumption

The number of commercial customers has been relatively stable, varying only between 5 and 6. As the proposed graphite mine at Deep Bay has been shelved at this time, there will not be the economic stimulus needed to increase the number of commercial customers over the period of the load forecast. The number of customers is assumed to remain stable at 6. The consumption of electricity, however, has increased between 1978 and 1983 at an average rate of 11.6% per annum. This rate of increase is considered to be unrealistic for any load projection and the same decreasing rate of increase used for the residential forecast was also used for commercial customers.

From Table 3.1, the average growth in the number of government customers was 7.5% per annum while the average increase in consumption of electricity was 11.6% per annum. The growth in the number of government customers appears to be out of step with the projected population growth of 1.74% per annum. To allow for an increase in the quality and extent of government services, an increase in the number of customers of 3.5% per annum was adopted. Again, a decreasing rate of increase in the consumption of electricity was used.

The projected load growth for these customers, as presented in Table 3.3 below, is based on the projected growth of both customers and consumption discussed above.

TABLE 3.3
PROJECTED LOAD GROWTH FOR COMMERCIAL AND GOVERNMENT CUSTOMERS AND STREET LIGHTS

Year	Consumption (kWhr)		
	Commercial	Government	Street Lights
1983	160 000	374 000	10 000
1984	179 000	437 000	11 000
1985	199 000	505 000	12 000
1986	220 000	578 000	13 000
1987	239 000	630 000	14 000
1988	258 000	706 000	15 000
1989	276 000	784 000	16 000
1990	293 000	860 000	18 000
1991	307 000	934 000	19 000
1992	320 000	1 004 000	20 000
1993	329 000	1 068 000	22 000
1994	336 000	1 157 000	23 000
1995	340 000	1 203 000	25 000

3.2.4 Heat Load

There are only a few residences reported to be using electric space heaters. Because of the restrictions on the use of electricity, these heaters are probably the 120 volt, plug-in type. The additional consumption of electricity by these heaters is likely to be small and the projected residential consumption discussed in Section 3.2.2 is considered to represent the non-heat electric load.

Residential heating is presently provided by oil and oil/wood furnaces in the Hamlet while all the residences on the Indian Reserve use wood solely. The reserves of wood within a 19 km radius of the community is estimated to be about 403,000 cords (ref. 3). At the present rate of consumption, this supply will last in excess of 1,000 years. As there are no proposed incentives to change from wood to electric heating, financial or otherwise, and because wood is also used for cooking on the Reserve, it is unlikely that there will be any significant load growth on the Reserve for heating purposes.

An energy conservation programme recently started by Saskatchewan Power will probably have a significant effect on the heat load for the Hamlet. The programme involves the displacement of fuel oil by using a hybrid heating system (ref.8). This system has been promoted with considerable success in the Provinces of Quebec, Ontario and Manitoba. The hybrid heating system involves the installation of electric heating elements in the plenum of an oil or oil/wood furnace: a system has not been developed for wood heaters at this time. The electric elements provide heating until the outside temperature drops below -19^{0}C when the furnace takes over. The heating system is rated at 9 kW and a device built into the system limits the total load to 80% of the capacity of the service entrance to the residence. This system has been demonstrated to displace between 80 and 85% of the fuel oil although Saskatchewan Power assumes a more modest figure of 75%.

Although there will be no increase in the capacity of the service entrance to residences using this system, there will be an increase in peak demand as most households do not fully utilize the capacity of the main breaker panel.

We expect that the potential reduction in heating costs will generate considerable interest and result in the eventual conversion of a significant percentage of the oil and oil/wood furnaces in the community to the hybrid system. Current federal grants and low interest provincial loans provide added incentives.

In 1982, approximately 189,000 litres of heating oil were consumed in the community (ref.1); 48,000 litres for residential use in the Hamlet, 12,000 litres for commercial use and the remainder by government services. This is equivalent to 1,485 MWhr of electrical load. It would make economic sense for both residential and government customers to convert to this type of heating system. It is less likely, however, that commercial customers will change because they are not eligible for the government grants or low interest loans.

In preparing Table 3.4, it has been assumed that all government customers and residential customers in the Hamlet will eventually convert to the hybrid system and that the increase in electricity consumption per customer for heating, based on the consumption of heating oil in 1982, is 2 percent per annum. Table 3.4 presents a fictitious case in which all these customers convert to this heating system in 1984. In reality, this will not occur: the effect of the date of commissioning of the hydro-electric development and gradual conversion is addressed in Section 3.4.

TABLE 3.4
PROJECTED HEAT CONSUMPTION FOR COMMUNITY OF SOUTHEND

Year	Consumption (kWhr)*		
	Residential (Hamlet only)	Government	Total
1984	319 000	896 000	1 215 000
1985	337 000	945 000	1 282 000
1986	355 000	998 000	1 353 000
1987	374 000	1 052 000	1 426 000
1988	394 000	1 110 000	1 504 000
1989	412 000	1 171 000	1 583 000
1990	434 000	1 236 000	1 670 000
1991	458 000	1 304 000	1 762 000
1992	487 000	1 375 000	1 862 000
1993	509 000	1 451 000	1 960 000
1994	537 000	1 531 000	2 068 000
1995	565 000	1 615 000	2 180 000

*Based on a total conversion to hybrid heating in 1984.

3.2.5 Total Energy Conversion

In order to determine the consumption associated with a total conversion from alternative energy sources to electricity, sources such as heating oil, propane and wood were converted to equivalent electrical energy for each group of customers. The consumption of these alternative sources in 1982 is presented in Table 3.5.

Table 3.5
NON-ELECTRICITY ENERGY CONSUMPTION IN SOUTHEND

	Consumption For 1982		
	Heating Oil (litres)	Propane (litres)	Wood (cords)
Residential	48 000	27 300	360
Government	129 000	36 200	5
Commercial	12 000	3 200	0
Total	189 000	66 700	365

In order to convert these sources to energy a conversion factor of 7.86 kWhr per litre of heating oil, 7.05 kWhr per litre of propane and 3.09 MWhr per cord of wood was used. Since the wood used on the Reserve has not been seasoned, a modest calorific value of 4 500 BTU per pound was used together with an efficiency of 65% for the wood heaters.

The projected load growth presented in Table 3.6, assumes an increase in the consumption of electricity per customer for total energy conversion of 2 percent per annum.

3.2.6 Load Factors and Peak Demand

The load factor, as used herein, is defined as the average annual demand at the load centre (for example, Southend) divided by the peak load at the generator. This load factor accounts for line and distribution losses.

The load factor for electric loads to Southend has increased from 0.33 in 1978 to 0.48 in 1983 . This is an average increase of 0.03 per annum. The load factor will probably continue to increase due to the market penetration of electric appliances and goods but at a more modest rate. It has been assumed that the load factor will increase at a rate of 0.01 per annum. Based on load factors for other northern communities a maximum load factor for non-heat electric loads of 0.53 was adopted for this study.

TABLE 3.6
PROJECTED ADDITIONAL ENERGY CONSUMPTION FOR TOTAL ENERGY CONVERSION

Year	Consumption (kWhr)			
	Residential	Commercial	Government	Total
1984	1 899 000	122 000	1 514 000	3 535 000
1985	2 002 000	124 000	1 597 000	3 723 000
1986	2 110 000	127 000	1 685 000	3 922 000
1987	2 224 000	129 000	1 778 000	4 131 000
1988	2 344 000	132 000	1 876 000	4 352 000
1989	2 446 000	134 000	1 979 000	4 559 000
1990	2 579 000	137 000	2 088 000	4 804 000
1991	2 719 000	140 000	2 202 000	5 061 000
1992	2 893 000	142 000	2 323 000	5 358 000
1993	3 023 000	145 000	2 451 000	5 619 000
1994	3 186 000	148 000	2 586 000	5 920 000
1995	3 360 000	151 000	2 728 000	6 239 000

*Based on all heating oil; propane and wood used by the community being replaced by electricity.

TABLE 3.7
PROJECTED PEAK LOADS FOR NON-HEATING LOADS

Year	Average Demand (kw)	Load Factor	Peak Demand (kw)
1984	133	0.49	271
1985	152	0.50	304
1986	173	0.51	339
1987	191	0.52	367
1988	212	0.53	400
1989	234	0.53	442
1990	254	0.53	479
1991	271	0.53	511
1992	286	0.53	540
1993	300	0.53	566
1994	318	0.53	600
1995	329	0.53	621

For the hybrid heating system, the peak heat load will be the difference between the peak load for non-heating loads and 80 percent of the total capacity of breaker panels in the buildings inclusive of all line and distribution losses. For residential loads, only houses in the Hamlet are equipped with oil or oil/wood furnaces suitable for conversion to this heating system. The Hamlet contains about 31.5% of the total number of houses in the community. To determine the maximum residential capacity, it was assumed that half of the existing houses have 70 amp breaker panels while the remainder and all new houses have 100 amp panels. Unfortunately, no information was available regarding breaker panels for government buildings. To determine the peak load for government customers, the non-heating peak load was multiplied by a factor of 3.56. This factor is the average ratio of peak load for non-heating purposes to the peak demand for heating for residences.

TABLE 3.8
PROJECTED PEAK LOAD FOR HYBRID HEATING SYSTEM

Year	Residential*				Government
	Breaker Panel *Capacity (kW)		Peak Non-Heat Load (kW)	Peak Heat Load (kW)	Peak Heat Load (kW)
	At Residence	At Generator			
1984	206	237	40	197	362
1985	214	246	45	201	410
1986	223	256	49	207	461
1987	231	266	54	212	492
1988	239	275	60	215	541
1989	248	285	66	219	601
1990	256	294	72	222	659
1991	267	307	75	232	716
1992	278	320	79	241	770
1993	286	329	82	247	819
1994	298	343	86	257	887
1995	309	355	89	266	922

* For Hamlet Only

To determine the electrical requirements for a total conversion of all non-electric energy sources, the consumption of these sources, expressed in an equivalent electrical consumption, was calculated for the year 1982. The equivalent consumption is presented on Table 3.9. A load factor of 0.25, based on temperature records at Whitesand Dam, was used to determine the peak load for the conversion of all non-electric energy sources.

TABLE 3.9
EQUIVALENT CONSUMPTION AND LOAD FOR ALL NON-ELECTRIC ENERGY SOURCES

Year	Total Equivalent Consumption (kWhr)	Average Load (kW)	Peak Load (kW)
1984	3 535 000	402	1 614
1985	3 723 000	425	1 700
1986	3 922 000	448	1 791
1987	4 131 000	472	1 886
1988	4 352 000	497	1 987
1989	4 559 000	520	2 082
1990	4 804 000	548	2 194
1991	5 061 000	578	2 311
1992	5 358 000	612	2 447
1993	5 619 000	641	2 566
1994	5 920 000	676	2 703
1995	6 239 000	712	2 847

3.2.7 Summary

The projected consumption of electricity and peak loads for the study period are presented in Table 3.10.

TABLE 3.10
PROJECTED TOTAL CONSUMPTION OF ELECTRICITY AND PEAK LOAD
FOR COMMUNITY OF SOUTHEND

Year	Consumption (MWhr)			Peak Load (kW)		
	Non-Heat Electricity	Hybrid Heating	Total Energy Conversion	Non-Heat Electricity	Hybrid Heating	Total Energy Conversion
1984	1 116	1 215	3 535	271	559	1 614
1985	1 335	1 282	3 723	304	611	1 700
1986	1 515	1 353	3 922	339	668	1 791
1987	1 675	1 426	4 131	367	704	1 886
1988	1 861	1 504	4 352	400	756	1 987
1989	2 049	1 583	4 559	442	820	2 082
1990	2 228	1 670	4 804	479	881	2 194
1991	2 371	1 762	5 061	511	948	2 311
1992	2 509	1 862	5 358	540	1 011	2 447
1993	2 629	1 960	5 619	566	1 066	2 566
1994	2 783	2 068	5 920	600	1 144	2 703
1995	2 885	2 180	6 239	621	1 188	2 849

3.3 Mine Loads

As discussed in Part 2, there are two areas of active exploration in the geographic area - in the Star Lake/Waddy Lake area and at Deep Bay. The mine at Deep Bay, which represents the largest load of 3000 kW, has been shelved and will probably not be reconsidered until the mid-1990's. The delay in developing this mine is a result of a soft market caused by the sale of graphite to the U.S.A. by China at prices that cannot be matched by Canadian mines.

This situation could quickly change, however, should the present cordial relationship between the U.S.A. and China become sour or if power costs, and hence production costs, for the mine can be reduced. The plans for the mine have not advanced to the stage where sufficient information is available to accurately assess the impact on the community of Southend. We anticipate that the community load would probably increase in the order of fifty percent. In the absence of more information, the peak load for the mine is assumed to be as given by SPC and that the load factors are the same as for the mine in the Star Lake/Waddy Lake area. Based on these assumptions, the electrical consumption at this mine will be approximately 15,900 MWhr per annum.

A gold mine in the Star Lake/Waddy Lake area could be commissioned by 1986. A feasibility study is almost complete and design should start early in 1985 (ref.9). Although the mine reserves are likely to only last between 3 and 3.5 years, the prospects are good for finding more gold in the area. It is anticipated that once a mill is in place this load will probably exist for between 10 and 15 years. Present studies indicate that the highest demand will be 200 hp at the mine and 640 hp at the mill. This gives a peak demand of 650 kW. To account for line losses, the turbine should be rated for 750 kW. The load factor is estimated to be 0.70. This represents an electricity consumption of 4,000 MWhr per annum. Any increase in this load caused by the concurrent development of other reserves has not been included in this study.

3.4 Brabant Lake

Discussions with North Sask Electric, Energy Mines and Resources Canada and the community of Southend have established that any hydro-electric installation at Whitesand Dam would also supply the community of Brabant Lake approximately 40 km southwest of Southend. Using information provided by North Sask Electric, the total consumption and peak demand for Brabant Lake in 1983 was 256,000 kWhr and 60 kW respectively. In lieu of a definitive evaluation of the community, it has been assumed that both the consumption of electricity and peak are increasing at the same rate as Southend. It has also been assumed that the ratio of the non-heat to hybrid heating for consumption and peak demand are the same as for Southend. With allowance for line and system losses, the peak Brabant Lake load in 1986 to be met by the initial installation would be approximately 100 kW.

3.5 Power Plant Capacity

Due to the lead time required to fabricate turbines, the proposed hydro-electric development could not be commissioned until 1986. This is also the earliest that the proposed gold mine in the Star Lake/Waddy Lake area could be opened. It is assumed that the hybrid heating programme will not be promoted until the hydro-electric plant is commissioned and that it will take ten years before all the oil and oil/wood furnaces are converted. The rate of conversion is assumed to be 10% of all customers in the Hamlet in 1986 increasing by 10 percent per annum such that all are converted by 1995. Table 3.11 and Figures 3.1 and 3.2, present the probable load forecast and peak demand for the community of Southend.

TABLE 3.11
PROJECTED CONSUMPTION AND PEAK LOAD
FOR SOUTHEND AND BRABANT LAKE

Year	Southend				Brabant Lake		Total	
	Non-Heat		Hybrid					
	Consumption (MWhr)	Peak Load (kW)	Consumption (MWhr)	Peak Load (kW)	Consumption (MWhr)	Peak Load (kW)	Consumption (MWhr)	Peak Load (kW)
1986	1 515	339	135	67	381	100	2 031	506
1987	1 675	367	285	141	452	126	2 412	634
1988	1 861	400	451	227	533	156	2 845	783
1989	2 049	442	633	328	619	191	3 301	961
1990	2 228	479	835	441	706	228	3 769	1 148
1991	2 371	511	1 057	569	791	267	4 219	1 347
1992	2 509	540	1 303	708	879	309	4 691	1 557
1993	2 629	566	1 568	853	968	352	5 165	1 771
1994	2 788	600	1 861	1 030	1 071	404	5 715	2 034
1995	2 885	621	2 180	1 188	1 168	448	6 233	2 257

Based on the projected peak demands for Southend and Brabant Lake, it is proposed to initially install one 750 kW unit to be in service by 1986 to supply these communities. A second unit will be required to be in service by 1988 with a third added by 1992. These units would satisfy projected requirements over the period of the load forecast.

We recommend that the existing diesel generating plant at both Southend and Brabant Lake be retained as back-up until the second 750 kV unit for the communities is commissioned. At this time, the diesel generators will be available for use elsewhere.

On the basis of the projected date of commissioning the proposed gold mine in the Star Lake/Waddy Lake area, it is proposed that the initial development include one 750 kW unit to supply this load. Based on the data provided by SPC for the proposed graphite mine at Deep Bay, a 3 X 1000 kW installation is assumed to be suitable to service this load.

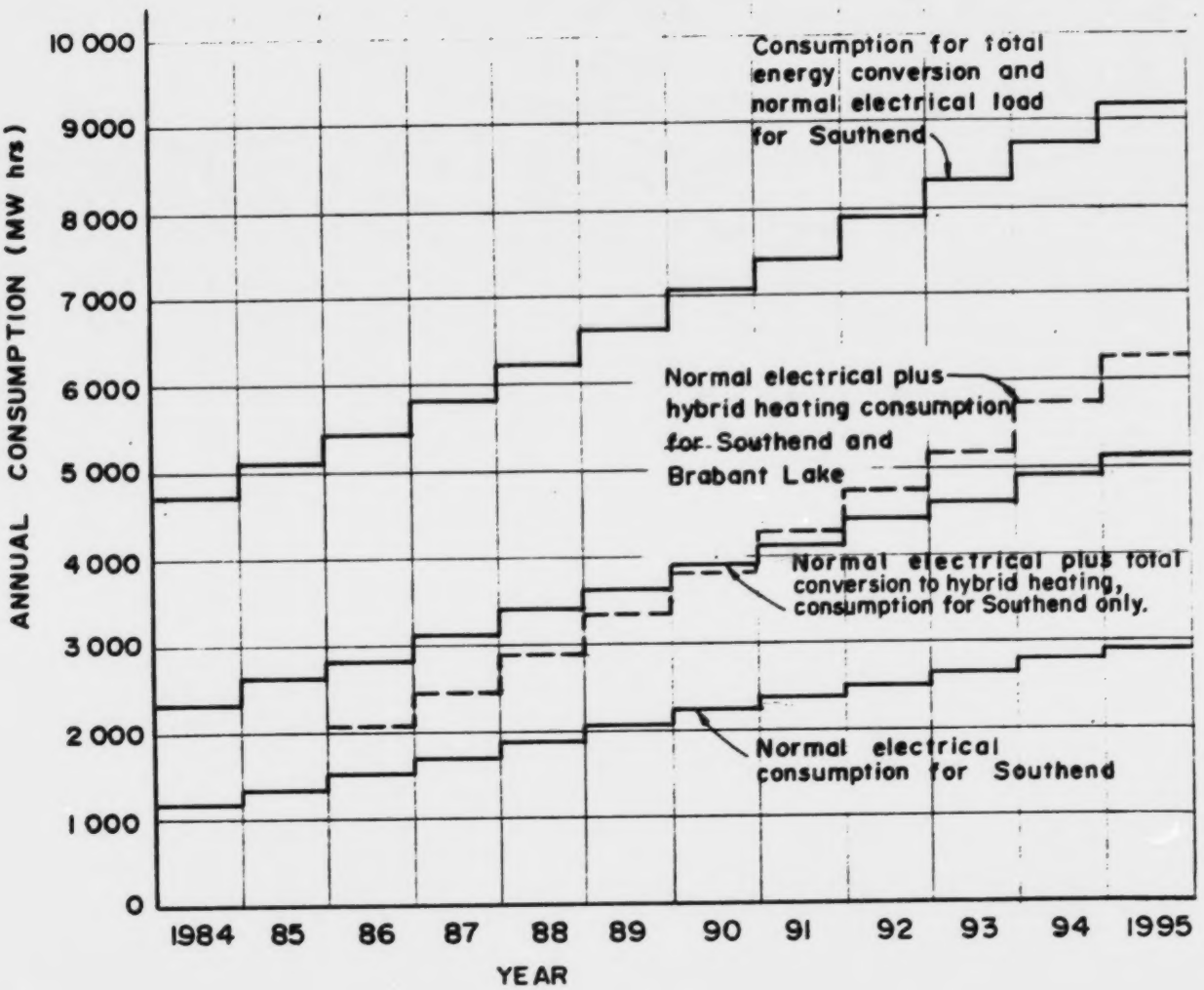


FIGURE 3·1
PROJECTED CONSUMPTION
OF ELECTRICITY FOR
SOUTHEND AND
BRABANT LAKE

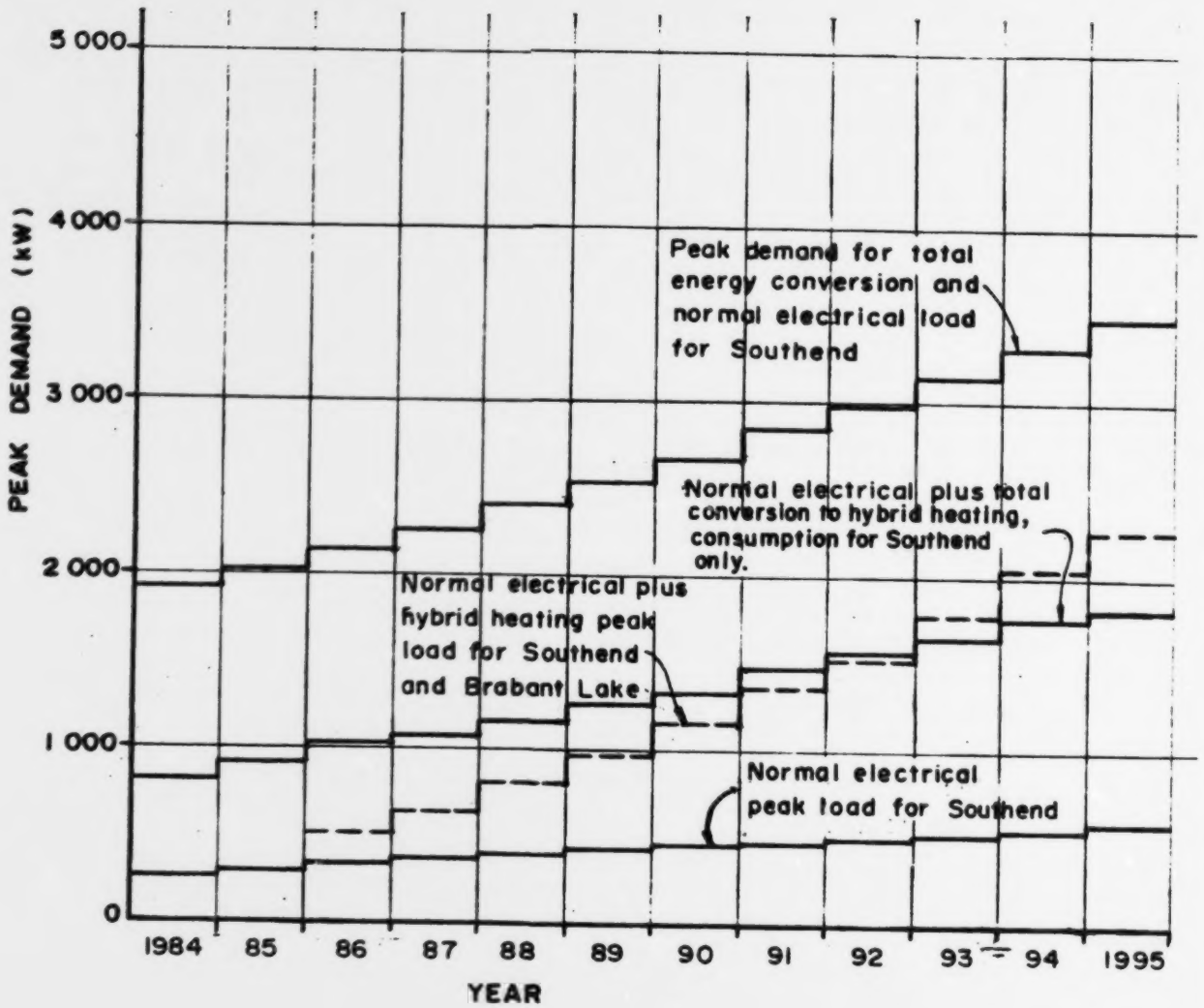


FIGURE 3·2
PROJECTED
PEAK LOAD FOR
SOUTHEND AND
BRABANT LAKE

PART 4 WHITESAND HYDRO-ELECTRIC DEVELOPMENT

4.1 ALTERNATIVE HYDRO-ELECTRIC SITES

Potential alternative sites for a hydro-electric development to supply power to the community of Southend were examined. The search was limited to the general geographic area. The two major watercourses that would provide the correct combination of head and flow are the Reindeer River downstream from Whitesand Dam and the Churchill River.

Sites on the Reindeer River downstream from Whitesand Dam include Devil Rapids and Steephill Rapids. Both sites require a dam and the access road, and transmission lines would be longer than required for Whitesand Dam. Neither site appears to offer any significant improvement over conditions encountered at Whitesand. For these reasons, further evaluation of these sites was not continued.

A good location for a hydro-electric development on the Churchill river is Otter Rapids. Otter Rapids is situated on the Churchill River where it is crossed by Highway 102. Again, this site requires a dam, but since the access road is short, a hydro-electric development here could be comparable with one at Whitesand Dam on the basis of capital cost.

Consideration of transmission line requirements and costs was excluded from the scope of this study. It should be noted, however, that the length of transmission lines associated with a development at Otter Rapids will be approximately 55 km, 130 km and 145 km for the mine in the Star Lake/Waddy Lake area, Southend and the mine at Deep Bay respectively compared with 115 km, 25 km and 40 km for the Whitesand Dam development.

Otter Rapids is located approximately 85 km north of La Ronge. The rapids link Devil Lake (elevation 351 m +) and Otter Lake (elevation 348 m +). The rapids are approximately 100 m wide and about 500 m long. The proposed damsite is at the upstream end of the rapids. The left bank and river channel at this point is comprised of bedrock while the right bank is comprised of till. In preparing the cost estimate shown in Part 5 and Appendix D, it was assumed that the dam would comprise concrete overflow and gravity sections and that the powerhouse and intakes would be one integral structure.

The average flow at Otter Rapids is 314 cms (cubic metres per second) which is very similar to the average of 322 cms measured at Whitesand Dam. It is likely, therefore, that the water supply is adequate for the proposed hydro-electric development. The monthly flow data published for both sites by Environment Canada is presented in Appendix C.

4.2 HYDROLOGY

The general hydrology of Reindeer Lake and Reindeer River was studied in detail by Crippen Acres (ref. 10). The work was part of an overall review of flows in the Churchill River, Wollaston Lake and Reindeer River. Since the construction of Whitesand Dam in 1942, the outflow from Reindeer Lake has been estimated by relating the discharge through the sluiceways to lake elevations. The Francis formula used to calculate the discharge was considered by Crippen Acres to be inaccurate because it assumed a constant coefficient of discharge. The discharges were revised using the Rehbock formula for sharp-crested weirs. The original and revised average monthly flows are presented in Appendix C. The difference between the flows varied from 3 to 20 percent with an average of 8 percent. A minimum flow of 6 cms was adopted to allow for leakage through the stoplogs.

Any difference between flow-duration curves determined on a mean monthly and on a mean daily basis are not likely to be significant for a control structure such as Whitesand Dam. Using this assumption, we can conclude that, for the period of record from 1929 to 1982, the flow required to maintain a 2 X 750 kW hydro-electric development at this site of 26 cms at the minimum net head of 6.8 m exceeded the measured discharge for only 6 months: in 1957, 1970 and 1982.

These shortfalls occurred during the summer when the demand for electricity will probably be below the turbine capacity and they amount to less than 1 percent of the period of record. For an additional 3 X 1000 kW development, time during which the recorded flow was less than the 52 cms required at the minimum head increased to 16 months or 2.5 percent of the period of record. Although again most occurred during the summer some of these events occurred during the winter, in early 1971.

The adjusted historical flows were used for this study as the report prepared by Crippen Acres (ref. 10) indicates that there would be no advantage in changing the current mode of operation of maximizing winter releases from Whitesand Dam.

The proposed development will have an insignificant effect on the present levels in Reindeer Lake and flows downstream except that low flows will be stabilized.

4.3 GEOLOGICAL AND GEOTECHNICAL EVALUATION

The geology and geotechnical aspects of this proposed development are discussed in detail in Appendix B. The report was prepared by Dr. Mollard and includes an appraisal of potential borrow areas and access road alignments. A site reconnaisance was also carried out to review general site conditions.

In general, the metamorphic bedrock in the vicinity of Whitesand Dam is overlain by sandy eskers, ablation and basal tills, and fine sand, silt and clay deposited in glacial Lake Agassiz. At the damsite, the left abutment comprises sand and sandy till over bedrock. Downstream from the dam, the bedrock outcrops just above the level of Fafard Lake (elevation 330 m +). Upstream, apart from the immediate dam abutment, only one outcrop of rock was observed.

The right abutment is comprised entirely of bedrock with only a thin, discontinuous mantle of topsoil. The centre island between the two sluiceways is comprised of a concrete wall and supporting fill placed on bedrock.

Locally obtainable materials required for construction of the proposed hydro-electric development are granular fill and concrete aggregate. Exposures found on the left abutment indicate the granular deposits at this location to be a fine, uniform sand. Little coarse material, suitable for concrete aggregate, was found and, in one location, the sand contained fragments of shale. It was not possible to examine any potential borrow areas on the right abutment because of dense brush. A large area of sand and gravel, till and boulders are expected on what appears to be a wave washed esker to the south-west of the damsite. These deposits should contain adequate quantities of coarse gravel for this development. Potential borrow areas are shown on Figure 4.1

In addition to improving the existing winter road from Island Falls by strengthening the ice crossings, possible routes of a new access road from Southend have been investigated. These routes are shown on Figure 4.1. Despite the rugged terrain, rock blasting is expected to be minimal and it should be possible to avoid most of the clay, peat and permafrost pockets typical of this region. These routes would be suitable for either a permanent all-weather or a winter road. It would not be practical to follow the transmission line due to the rocky nature of the route from Southend to Whitesand Dam proposed by North Sask Electric. The cost estimates were prepared assuming the construction of a winter road from Southend to the site.

4.4 THE PROPOSED DEVELOPMENT

4.4.1 Temporary Works

The decision to minimize any interference with the operation of the existing sluiceways, while prudent, places constraints on the temporary works. In general, any temporary works such as cofferdams must not encroach on the sluiceway openings.

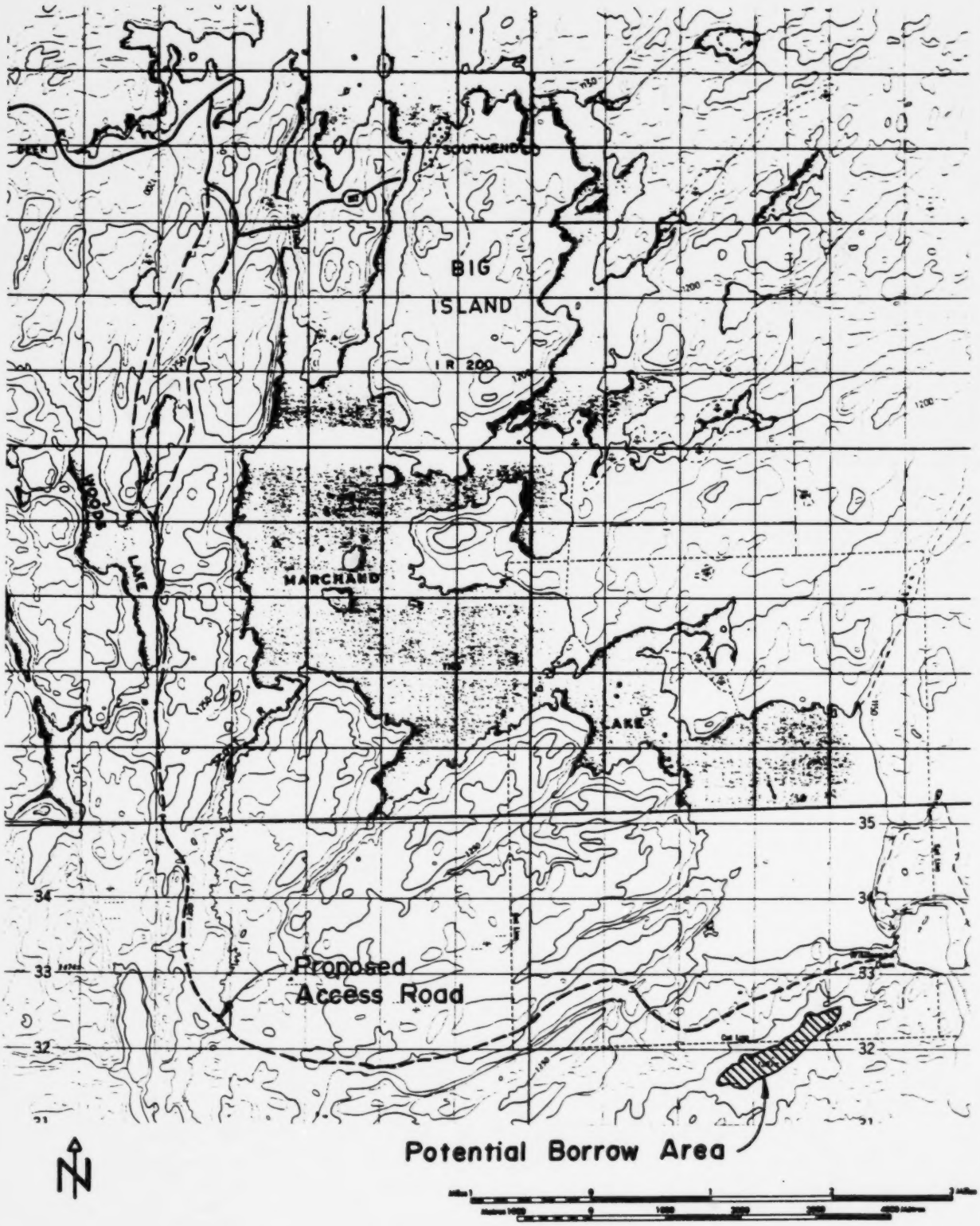


Figure 4·1

Borrow Areas and Access Road

In order to construct a conventional gravity intake, a cofferdam is required on the upstream side of the intake. Because the forebay is comprised of bedrock, only an earthfill cofferdam is feasible. It can be seen on the site plan, Figure 4.2, that it would not be possible to construct a cofferdam to enable construction of an intake on the left abutment or centre island without completely blocking the left sluiceway and part or most of the right sluiceway. An intake channel will be required for an intake located on the right abutment to provide the required submergence. A cofferdam to enable construction of the channel would restrict the openings on the right sluiceway. For these reasons, it was decided to abandon the use of a conventional gravity intake in favour of a syphon intake. This type of arrangement does not require the construction of cofferdams: divers would prepare the foundations and make any underwater connections.

Although the existing site information downstream from the dam does not extend far into Fafard Lake, the contours, shown on Figure 4.2, indicate that the shore of Fafard Lake falls off steeply. The depth of water downstream from the dam, although not known, could be as much as 7 to 10 m. The bottom of Fafard Lake is expected to be bedrock with only a thin cover of silt, sand and gravel, suitable only for an earthfill cofferdam. The cost of this type of cofferdam would make the construction of a conventional powerhouse with a mass or reinforced concrete substructure uneconomic compared with a steel framed substructure. Again, divers would prepare the foundation and make any underwater connections.

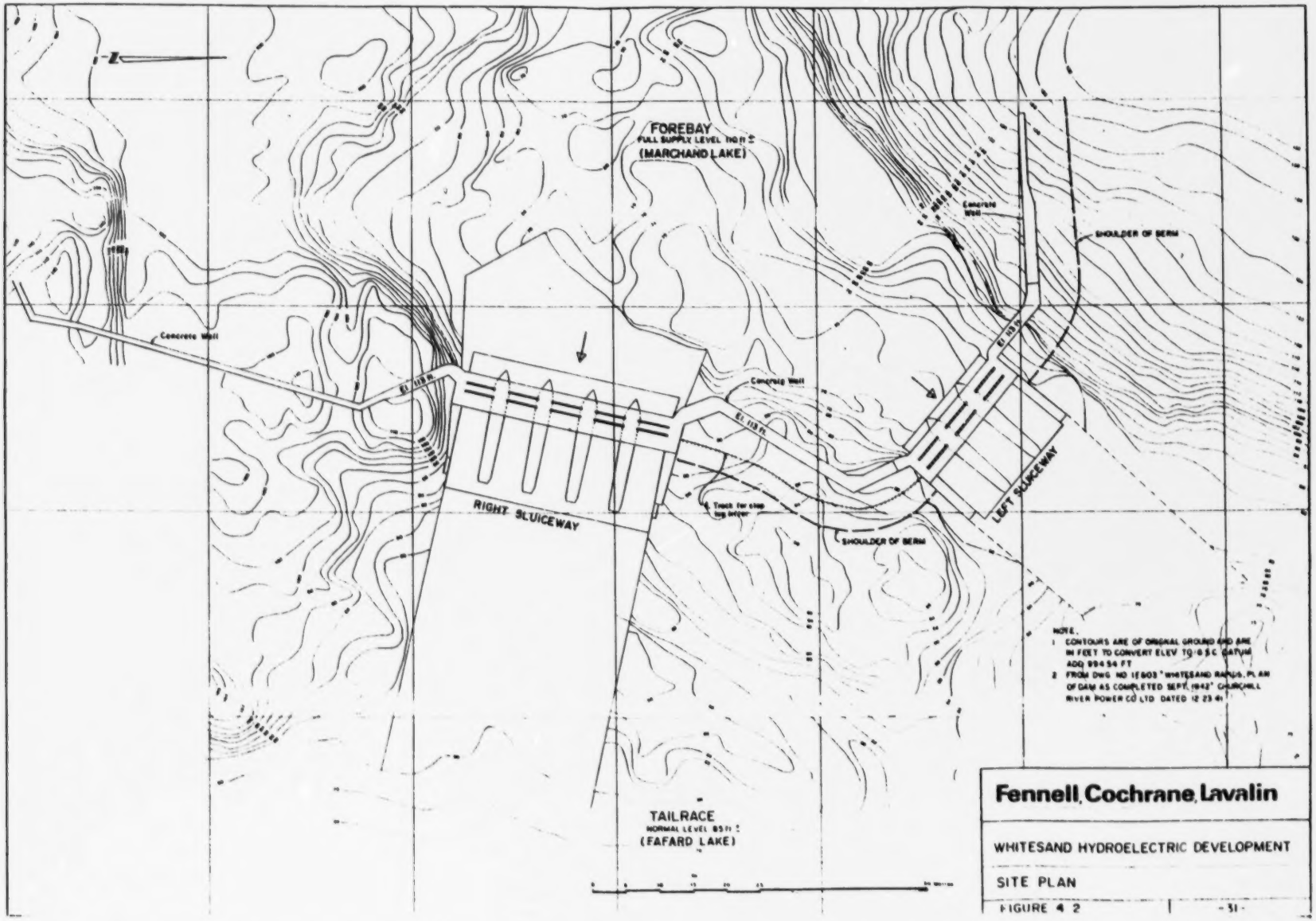
Because the dam already exists, no unwatering works are required during construction.

4.4.2 Turbine Selection

The use of a steel framed substructure for the powerhouse restricts the turbine selection. Units like the tube or S-type turbine that need to be encased in concrete cannot be considered. Types of turbine like the Hydrolec turbine, with a range of outputs restricted to 300 kW or less, were not considered either. It is preferable when considering maintenance, repairs and spare parts to use the same manufacturer and type of turbine, and as such, the use of such small units require a greater number of turbines and would result in unduly large powerhouses.

The turbines selected for consideration were;

- the cross-flow Banki turbine by Ossberger;
- Kaplan turbine by Barber Engineering; and
- Turbogen by Waterwheel Erectors


FOREBAY
FULL SUPPLY LEVEL 1101 ft ±
(MARCHAND LAKE)
Concrete Wall
El 113 ft
Concrete Wall
El 113 ft
RIGHT SLUICEWAY
Track for stop log lifter
SHOULDER OF BERM
SHOULDER OF BERM
El 113 ft
LEFT SLUICEWAY
TAILRACE
NORMAL LEVEL 851 ft ±
(FAFARD LAKE)
NOTE.
1 CONTOURS ARE OF ORIGINAL GROUND AND ARE IN FEET TO CONVERT ELEV TO G S C DATUM ADD 994 54 FT
2 FROM DWG NO 1E803 "WHITESAND RAPIDS PLAN OF DAM AS COMPLETED SEPT 1942" CHURCHILL RIVER POWER CO LTD DATED 12 23 41
Fennell, Cochrane, Lavalin
WHITESAND HYDROELECTRIC DEVELOPMENT
SITE PLAN
FIGURE 4 2
- 51 -

Sectional views of these turbines are presented in Figure 4.3. Since information on the performance characteristics could not be obtained at this time, turbines have not been optimized with regard to rated capacity.

Following is a brief description of these turbines.

Cross-Flow Turbine

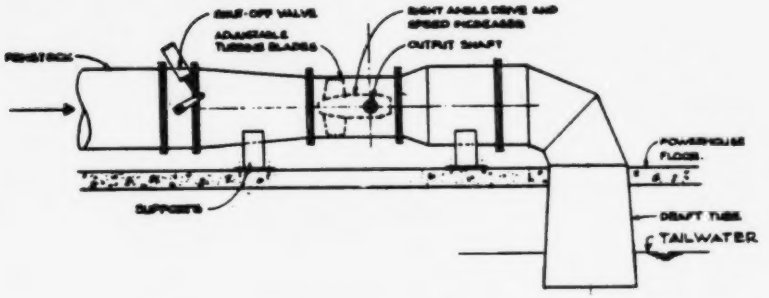
The cross-flow turbine is a semi-impulse machine that, unlike the Pelton or Turgo wheels, operates with a draft-tube vacuum, and therefore utilizes the full head between the forebay and trailrace. The main characteristic of this type of machine is a broad water jet of rectangular cross-section which passes twice through the turbine blades. The regulating apparatus for this turbine consists of one or more guide vanes located upstream of the runner. A simple draft tube is used to develop a suction head. At present, this type of turbine can only be installed with a horizontal axis.

Compared to other types of turbine, the cross-flow reportedly has a characteristic flat efficiency curve. The peak efficiency is not as great as other types of turbines. By using multiple guide vanes, however, an efficiency of over 80% is achieved for gate openings from 100% down to 20%.

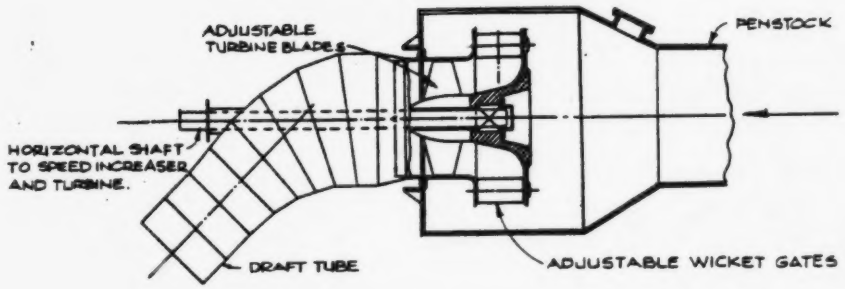
Several of these units have been installed in Canada and owners' experience with them has been good. Newfoundland and Labrador Hydro recently installed a 440 kW unit at Roddickton as a joint undertaking with Energy, Mines and Resources Canada. A report (ref. 11) on this installation is available. A representative from Newfoundland and Labrador Hydro indicated that there have been no contractual problems and that the installation went smoothly. The unit has run well since it was commissioned and Newfoundland and Labrador Hydro would not hesitate to install another unit from this supplier.

One significant disadvantage with this turbine is that the largest unit available will only produce 415 kW of firm power at this site. The support members for this turbine are also usually embedded in second stage concrete making salvage difficult.

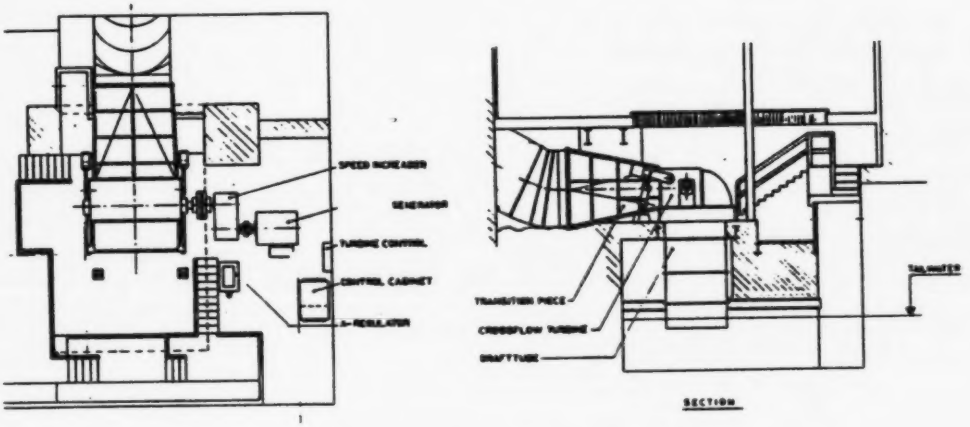
The turbine is manufactured in Europe and the electrical equipment, transition piece and draft-tube can be obtained in Canada to qualify under the "Made in Canada" clause. The speed increaser, if required, may also be obtained in Canada.



TURBOGEN TURBINE



KAPLAN TURBINE



CROSS-FLOW TURBINE

Figure 4·3
Sectional Views of Turbines

Kaplan Turbine

The Kaplan turbine is an axial flow reaction turbine with adjustable runner blades. This type of turbine is well suited for low head operation. Because the runner blades are adjustable, the pitch can be varied to provide optimum performance under different heads. The result is an efficiency curve that is flatter than for fixed blade machines but not as flat as the cross-flow turbine. Due to the variation in both head and load, adjustable blades are necessary.

Conventional Kaplan turbines usually have both adjustable blades for variation in head and adjustable wicket gates for variation in power demand. This machine is well known for its reliability.

Barber Engineering has recently developed the mini-Hydel. This is a self-contained prefabricated generating station which includes the turbine, generator, control and protection. All that is required to complete the powerhouse is a foundation. This installation can be fitted with either propeller, Kaplan or Francis runners. Barber has advised us, however, that the mini-Hydel is not available for outputs greater than 500 kW at this time because of vibration problems associate with the height of the machine. A more conventional arrangement is proposed for this project. Barber has supplied two of the mini-Hydel units to Ontario Hydro (ref. 12). Despite problems with the gear boxes, Ontario Hydro is pleased with Barber's performance and has placed them on its list of hydraulic equipment suppliers. This turbine would have a high Canadian content and, apart from the runner blades, parts will be readily available.

Kaplan turbines are generally surrounded in part or wholly by second stage concrete making salvage difficult should this site be flooded by a dam constructed downstream.

Turbogen Turbine

The Turbogen turbine is a semi-Kaplan turbine with a built-in step up gearbox. This is an axial flow machine placed in what is termed a "straight-flow" arrangement, that is, the turbine housing is a straight continuation of the penstock. The Turbogen can be fitted with adjustable runner blades but, because of the arrangement, it does not have wicket gates. Resistors could be used to cope with load variations. Like the conventional Kaplan turbine, this machine is well suited for low head applications.

None of these turbines have been installed to-date, but the equipment has been well tested and proven under service conditions more severe than those encountered at the hydro-electric installation. The runner blades and gearboxes are the same as those found in marine bow thrusters: bow thrusters are used to manoeuver large ships in confined spaces.

The turbines and gearboxes are manufactured in the U.K. Auxiliary controls, generator casing and draft tube could be obtained from Canada to increase the Canadian content. Except for the runner blades, parts are generally readily available.

The unit is normally supplied with steel channel legs with base plates for bolting to a concrete slab and would be the easiest of the three to salvage should this become necessary.

Cost Comparison

Although we only received a budget estimate for the Turbogen turbine, it was possible to undertake a cost comparison of these units using in-house data and information. This cost data, presented in Table 4.1, does not include any indirect construction costs or engineering services.

Based on this table, the cost of the equipment for a 2 x 750 KW installation is $1,410,000 for the cross-flow, $1,020,000 for the Kaplan and $950 000 for the Turbogen turbine. For a 3 x 1,000 kW installation, the costs would be $2,820,000 for the cross-flow, $2,030,000 for the Kaplan and $1,630,000 for the Turbogen. These figures include an adjustment in the cost of the equipment for multiple units: there will probably be no reduction in the cost of delivery to site and installation.

In both cases, the Turbogen turbine gives the lowest cost. To allow for possible variations in the exchange rate for Sterling, the costs for the similar Kaplan turbine have been used for the cost estimates while the powerhouse layout is based on the Turbogen unit. The layouts of both powerhouses are shown on Figures 4.4 and 4.5.

Table 4.1
RELATIVE COSTS OF TURBINES AND GENERATORS

	Type of Turbine		
	Cross-flow	Kaplan	Turbogen *
Rated Capacity (kW)	415	750	750
Speed (rpm)	450	360	360
Turbine cost	$ 263 000	$ 336 000	$ 292 000
Generator Cost	$ 119 000	$ 196 000	$ 196 000
Total Cost	$ 382 000	$ 532 000	$ 488 000
Rated Capacity (kW)		1000	1000
Speed (rpm)		277	277
Turbine cost		$ 472 000	$ 333 000
Generator cost		$ 262 000	$ 262 000
Total Cost		$ 734 000	$ 595 000

* Note that turbine costs are sensitive to the exchange rates.

4.4.3 Alternative Alignments

The principal objective of this study is to produce a layout which takes full advantage of the site conditions and, in doing so, will provide the least cost for the proposed hydro-electric development.

With this in mind, alternative alignments for the intake, penstock and powerhouse on both abutments and the centre island were evaluated.

A hydro-electric development placed on the left abutment was eliminated early in this investigation as the intake would have to be placed in the entrance channel to the left sluiceway and the powerhouse in the tailrace. Although this sluiceway is only operated in an emergency, its use could result in damage to both the intake and powerhouse.

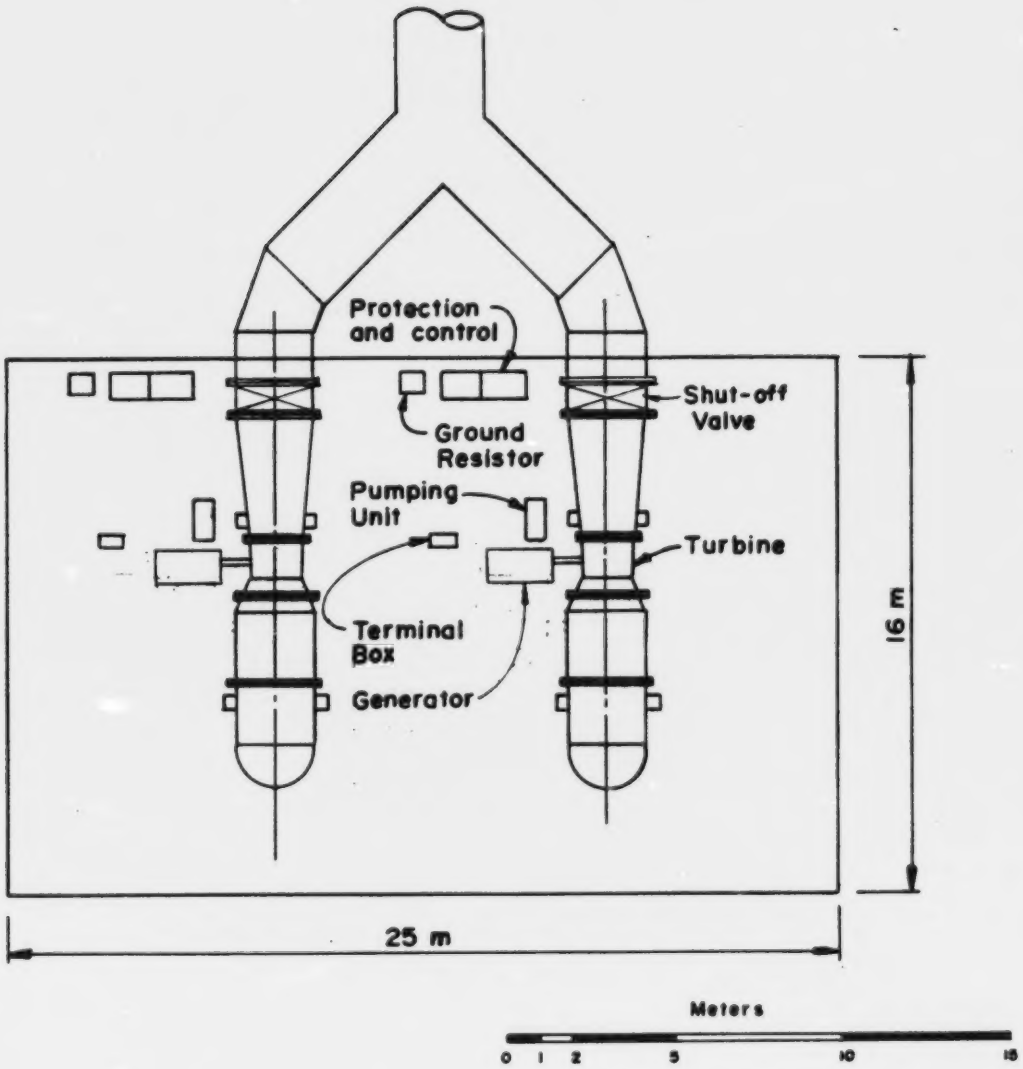


Figure 4·4
Plan of 2x750 kW Powerhouse

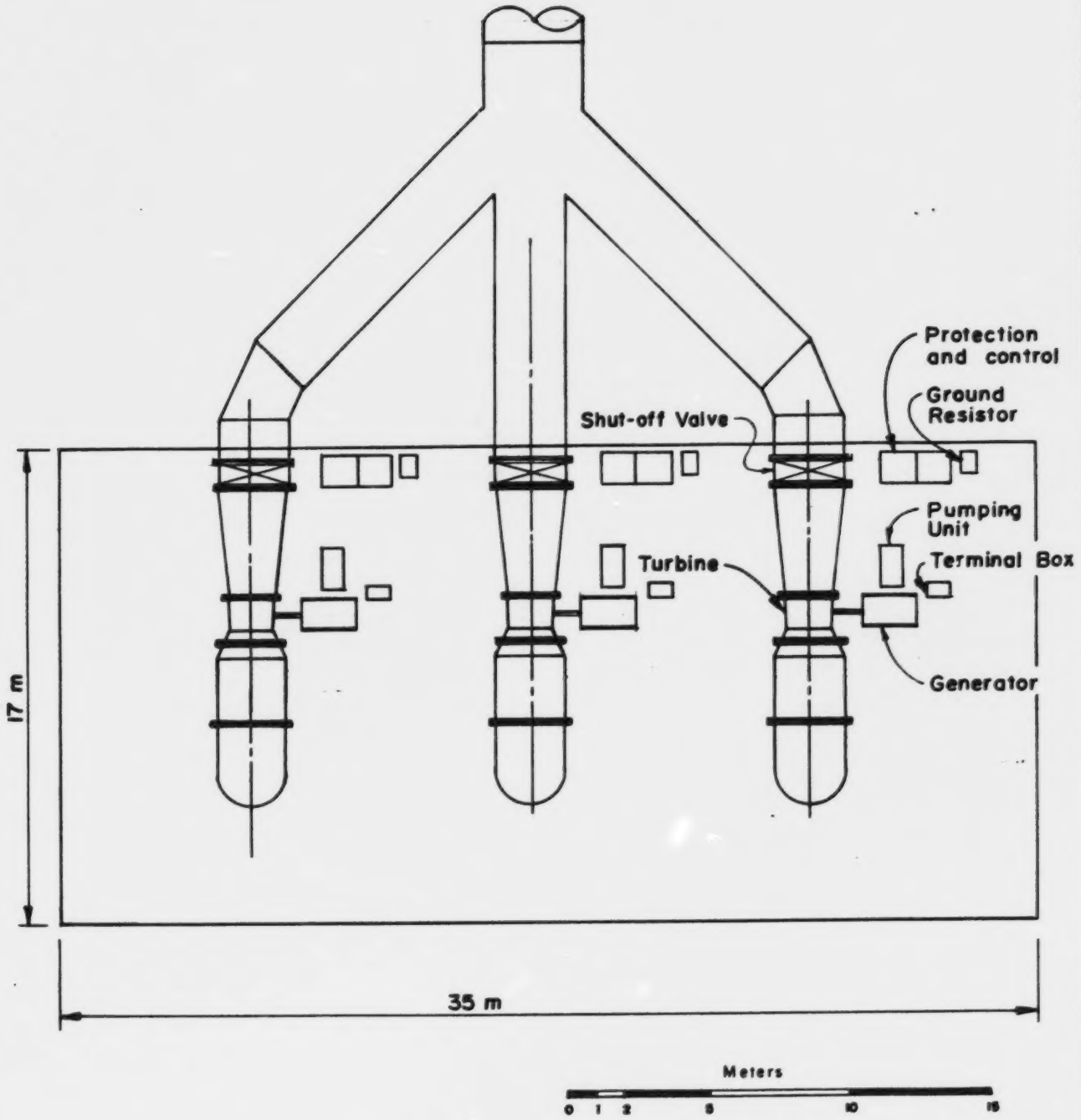


Figure 4·5
Plan of 3x1000 kW Powerhouse

The centre island was selected as providing the best location for the development. The depth of water upstream from the concrete retaining wall will provide the required submergence for the intake and the bedrock foundation is fairly level. The penstock will be located on rock as will the powerhouse. One disadvantage of this location is that the tracks for the stoplog lifter will have to be realigned and the berm built out accordingly to provide enough room between the stoplog lifter and the concrete wall for the penstock. Any re-alignment of the tracks would only be undertaken after the spring flood had subsided. Saskatchewan Power has indicated that this would be acceptable. If not, another stoplog lifter could be installed at a cost of $80,000.

As the centre island provides the best site, the initial 2 X 750 kW development should be placed here. There is not sufficient room on the centre island for both the initial 2 x 750 kW development to supply Southend and the proposed gold mine in the Star Lake/Waddy Lake area and the 3 x 1,000 kW to supply the proposed graphite mine at Deep Bay. It is possible, however, to place a duplicate 2 x 750 kW installation alongside the initial development should additional units be required to supply either Southend or the proposed gold mine.

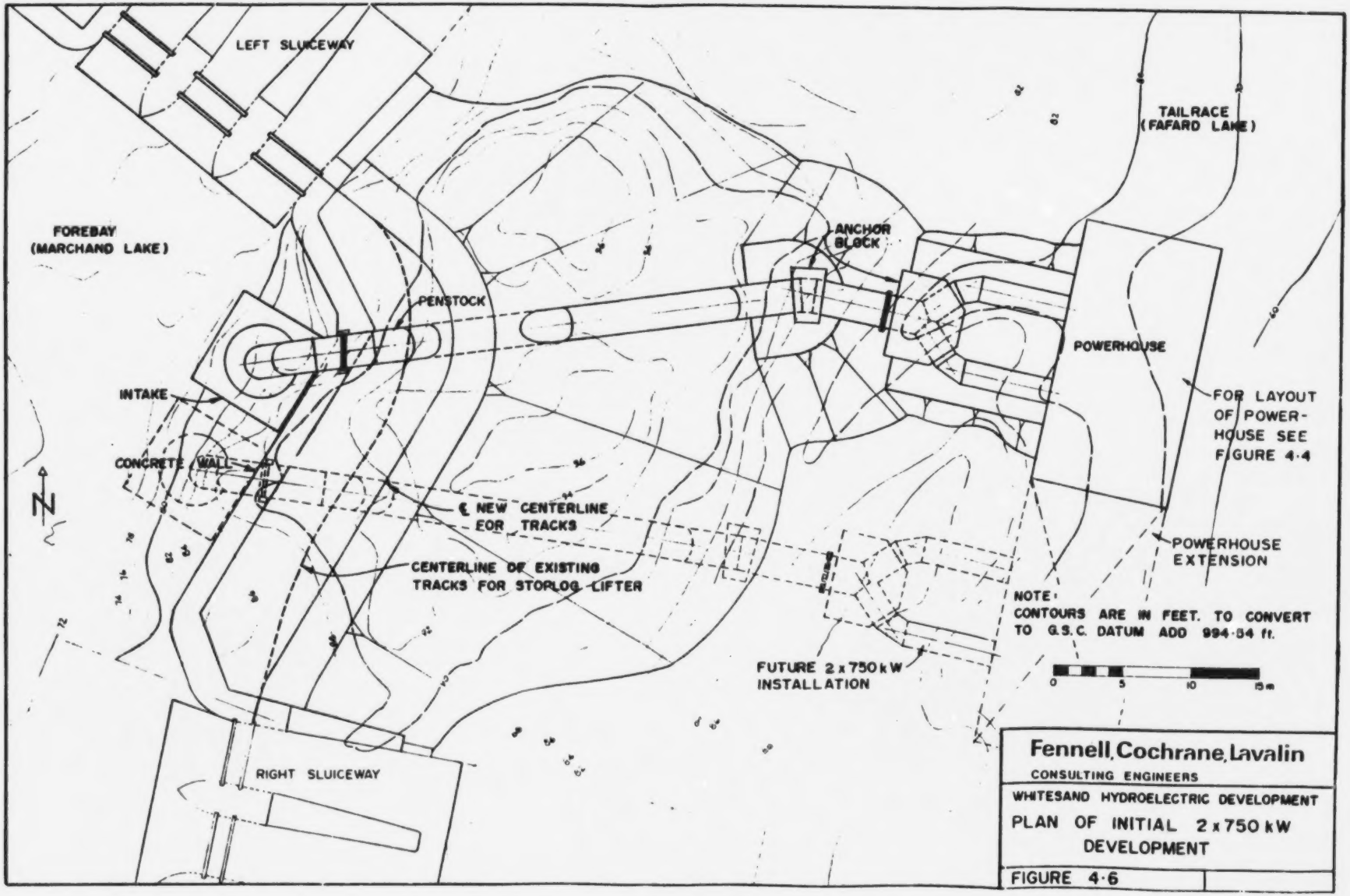
We propose to place the 3 x 1,000 kW development on the right abutment. This location is suitable although the intake has to be placed well into the forebay to provide adequate submergence. The penstock will be longer and the intake more difficult to construct. Should additional units be required it is possible to construct another 3 x 1,000 kW development at this location.

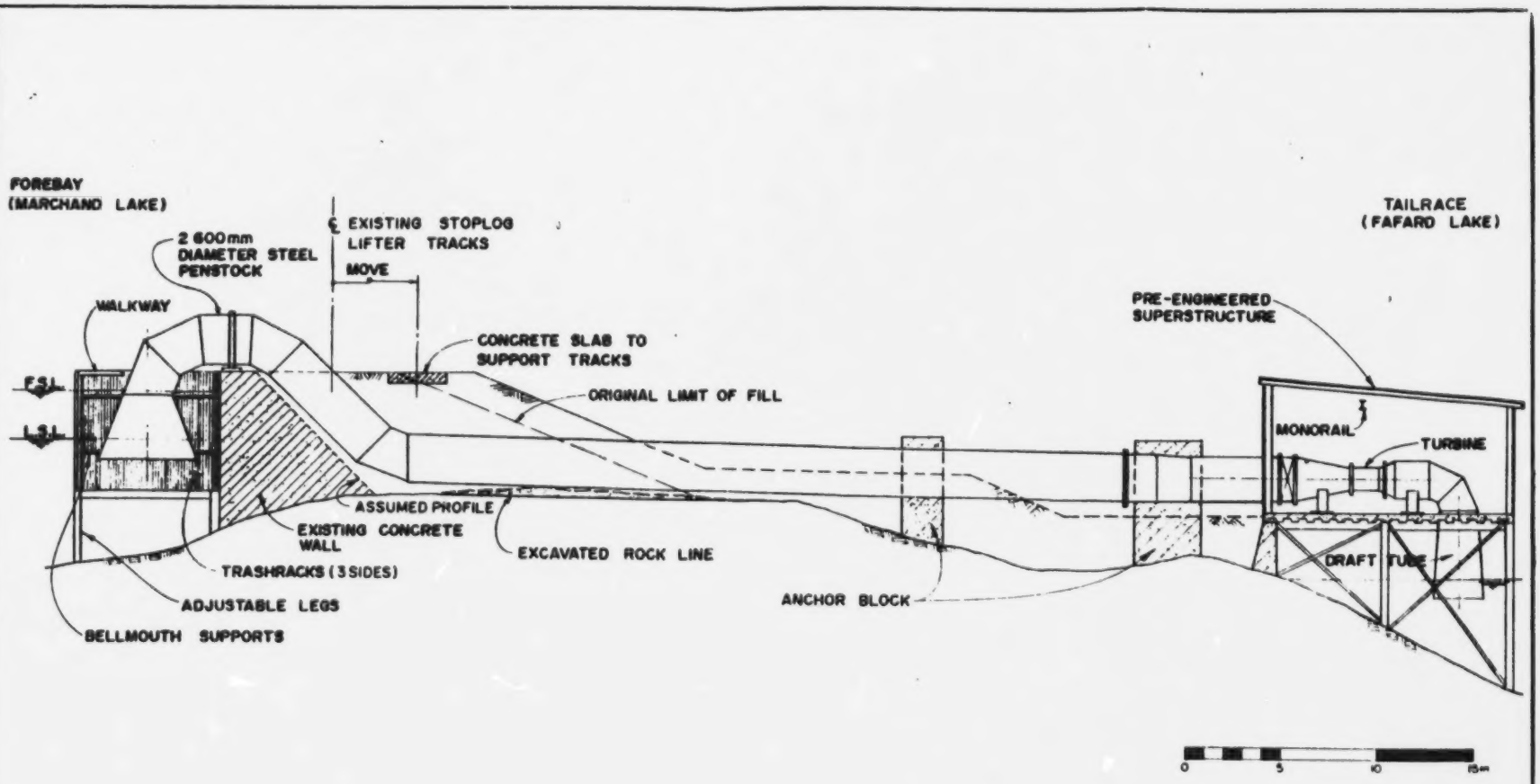
The plan and profile for both proposed developments are shown in Figures 4.6 to 4.9 inclusive. These layouts represent the least cost arrangements, although some reduction in cost could be possible when items, such as the steel penstock, are optimized.

When preparing the layouts, we have attempted to maximize the fabrication of components off-site and therefore minimize the duration and cost of site construction. This is important because of the short construction season at the site and the need to transport materials to site using a winter road.

4.4.4 Intake and Penstock

The arrangement of the intake and penstock is similar to that used at the Wasdell Falls Mini-Hydro development in Ontario. The proposed intake is a prefabricated unit with trashracks on three or four sides, depending on the location. Some problems have been experienced at Wasdell Falls with the build-up of leaves on the trashracks resulting in a loss of suction on the syphon. We do not anticipate this to be a problem at Whitesand as Saskatchewan Power has a permanent superintendent at the site. As a precaution, we propose to place grating on the floor of the intake to provide an additional flow path should trash build up on the racks. The racks would have to be manually raked.


LEFT SLUICEWAY
TAILRACE (FAFARD LAKE)
FOREBAY (MARCHAND LAKE)
ANCHOR BLOCK
PENSTOCK
POWERHOUSE
INTAKE
FOR LAYOUT OF POWER-HOUSE SEE FIGURE 4·4
CONCRETE WALL
℄ NEW CENTERLINE FOR TRACKS
POWERHOUSE EXTENSION
CENTERLINE OF EXISTING TRACKS FOR STOPLOG LIFTER
NOTE: CONTOURS ARE IN FEET. TO CONVERT TO G.S.C. DATUM ADD 994·84 ft.
FUTURE 2 x 750 kW INSTALLATION
0 5 10 15 m
RIGHT SLUICEWAY
Fennell, Cochrane, Lavalin
CONSULTING ENGINEERS
WHITESAND HYDROELECTRIC DEVELOPMENT
PLAN OF INITIAL 2 x 750 kW DEVELOPMENT
FIGURE 4·6



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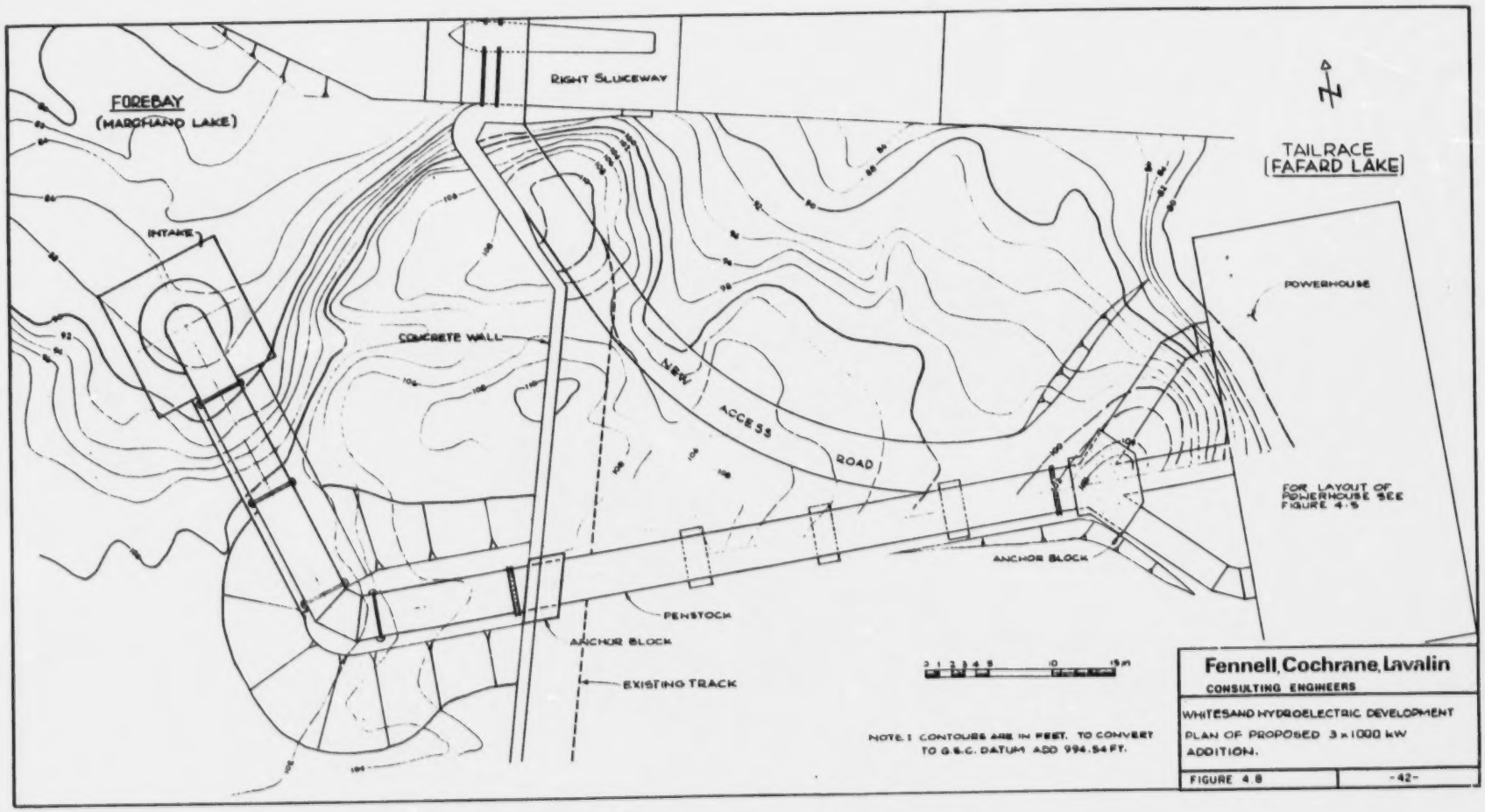
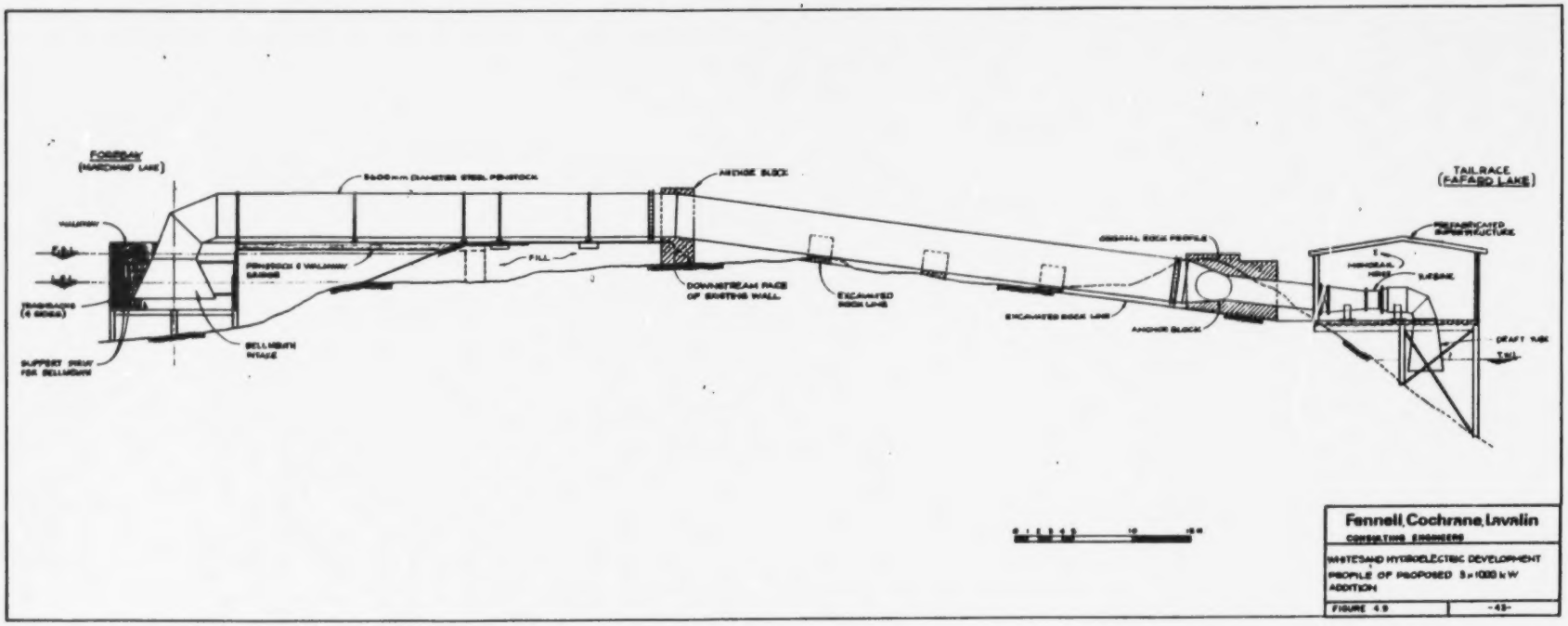
CONSULTING ENGINEERS

WHITESAND HYDROELECTRIC DEVELOPMENT
PROFILE OF INITIAL 2 x 750kW
DEVELOPMENT

FIGURE 4·7


FOREBAY
(MARCHAND LAKE)
RIGHT SLUICEWAY
TAILRACE
(FAFARD LAKE)
INTAKE
CONCRETE WALL
NEW ACCESS ROAD
POWERHOUSE
FOR LAYOUT OF POWERHOUSE SEE FIGURE 4.9
ANCHOR BLOCK
PENSTOCK
ANCHOR BLOCK
EXISTING TRACK
NOTE: 1 CONTOURS ARE IN FEET. TO CONVERT TO G.S.C. DATUM ADD 994.54 FT.
Fennell, Cochrane, Lavalin
CONSULTING ENGINEERS
WHITESAND HYDROELECTRIC DEVELOPMENT
PLAN OF PROPOSED 3 x 1000 kW ADDITION.
FIGURE 4.8
-42-


FOREBAY
(HARCHAND LAKE)
TAILRACE
(FAFARD LAKE)
ANCHOR BLOCK
DOWNSTREAM FACE OF EXISTING WALL
EXCAVATED ROCK LINE
ANCHOR BLOCK
DRAFT TUBE
Fennell, Cochrane, Lavalin
CONSULTING ENGINEERS
WHITESAND HYDROELECTRIC DEVELOPMENT
PROFILE OF PROPOSED 5 x 1000 kW ADDITION
FIGURE 4.9
-43-

Static ice is not expected to pose any design problems as the forebay has not been known to form a continuous ice cover since the dam was first commissioned. Frazil and slush ice have been observed by the dam superintendent and we recommend that provision be made for heating the trash racks should a build up of this ice occur.

The penstock is assumed to be steel. Alternative materials such as polyethylene have not been used for pipes of the size required for this development. Glass reinforced plastic has been used on occasion but is not recommended for this project. Besides being sensitive to ultra-violet radiation, pipe made from this material has to be either continuously supported or buried. Concrete has not been considered because of the weight penalty.

In order to fill and prime the penstock and intake, the valve provided in the powerhouse will be closed and the section of penstock between the powerhouse and syphon filled with water. To fill and prime the intake and syphon, air will be evacuated from the syphon, drawing water into the penstock from the reservoir. Once primed, the valve at the powerhouse can be opened to operate the turbine.

Particular attention will have to be given to the design of expansion joints where the penstock is subjected to subatmospheric pressure. The joints will have to be designed to prevent air entering the pipeline. This will not present a problem for the 2 X 750 kW development on the centre island as the only expansion joint, upstream from the powerhouse anchor block, can be placed below the hydraulic grade line. Without extensive rock excavation, it is not possible to place the expansion joints below the hydraulic grade line for the 3 X 1000 kW development on the right abutment.

The bellmouth intake has been sized for an inlet velocity of 1.25 m/s and the penstock has been sized for a velocity of 5 m/s at full turbine capacity.

4.4.5 Powerhouse

The proposed powerhouse is a free standing structure with a steel frame substructure, concrete floor slab and insulated prefabricated steel superstructure. To prevent the corrosion of steel members in the "splash zone", these members should be encased in concrete.

The layouts of the powerhouses have been based on the Turbogen turbine and are shown on Figures 4.4 and 4.5. The floor elevation for the powerhouse has been established by calculating the maximum allowable draft head for the turbines. To ensure that this elevation will give adequate protection against floods, the stage-discharge curve for Fafard Lake, Appendix C, was used.

4.5 Additional Studies

During the course of this project, we have identified what additional studies are required before final design is started. They are as follows:

4.5.1 Aerial Mapping

The available aerial photography of the area was taken at a high altitude and subsequently at a small scale. While these photographs were suitable for the purposes of this study, the proposed route of the access road should be re-photographed at a larger scale, say 1:12 000, to enable a final route to be selected. Ground control and compilation of maps would not be necessary. Note that this work will only be required if an access road is to be constructed.

Estimated Cost = $5,000.

4.5.2 Ground Survey

The existing contour map of the site (Scale 1" = 20 ft.) does not cover enough of the right abutment. A site visit indicated that a better site for the 3 X 1000 kW development exists south-west of that shown on Figure 4.8. The contour information of the bottom of Fafard Lake is also inadquate for locating the powerhouses. Additional survey work is required to obtain this information. The survey crew should also confirm the existing contour plan and downstream profile of the concrete dam on the centre island. The downstream face is presently covered with fill.

The stage-discharge relationship for Fafard Lake does not extend far enough to allow the turbine floor elevation to be set. Additional survey work is required to establish accurate cross-sections and profiles where the level of Fafard Lake, downstream from the dam, is controlled. With this information, the stage-discharge curve could be extrapolated with some confidence.

Estimated Cost = $15,000.

4.5.3 Geotechnical Site Investigation

The geotechnical site investigation would be limited to determining the extent of the borrow areas and required processing of material. A site visit confirmed that the proposed development is located almost entirely on sound bedrock and, apart from an inspection by divers to determine the depth of any alluvial deposits over the bedrock in the vicinity of the powerhouses and intakes, no additional investigations are considered necessary.

Portable drilling equipment would not be suitable for investigating granular deposits and, due to the isolated nature of the site, it would not be possible to get a heavier drill to the borrow area. We propose to have the test pits dug by hand, provided labour is available from the community of Southend. Personnel would be provided to supervise the work and log results. Samples would be obtained for laboratory analysis. A report would be prepared summarizing this study.

Without having seen these deposits, it is difficult to estimate the time required to hand excavate the pits with any degree of accuracy. The estimated cost of this investigation presented below should therefore be regarded as "order of magnitude" only.

Estimated Cost = $10,000.

4.5.4 Underwater Inspection

It would be desirable to know the depth of any sediment deposits and condition of the bedrock in the vicinity of the powerhouses and intakes. This would enable an accurate assessment of the size and length of support members for these structures and the extent of the necessary foundation preparation.

Estimated Cost $5,000.

4.5.5 Turbine Evaluation

We recommend further evaluation of the alternative types of turbine to confirm the selection of the Turbogen units. With a commitment to proceed with this project we anticipate that suppliers would be prepared to provide the necessary information. It should be noted, however, that based on information received at this time only the Turbogen unit could be supplied in time for delivery to site during the 1985/86 winter.

The lead times for delivery would be confirmed as part of this evaluation. Data received would contribute directly to the preparation of the turbine specifications.

Estimated Cost $18,000.

4.5.6 Summary

The additional studies listed below are recommended to be undertaken prior to final design.

TABLE 4.2
ADDITIONAL STUDIES

STUDY	ESTIMATED COST
Aerial Mapping	$ 5,000
Ground Survey	15,000
Geotechnical Site Investigation	10,000
Underwater Inspection	5,000
Turbine Evaluation	18,000
TOTAL	$53,000

PART 5 ECONOMIC EVALUATION

5.1 INTRODUCTION

In accordance with the findings of Part 3, Load Forecast, the following hydro-electric units will be required:

1) To supply the community of Southend and Brabant Lake, one 750 kW unit to be commissioned in 1986, one 750 kW unit in 1988 and one in 1992. By the end of the projected forecast, all three units will be fully utilized in terms of demand.

2) One 750 kW unit to supply the proposed gold mine in the Star Lake/Waddy Lake area.

3) Three 1000 kW units to supply the proposed graphite mine near Deep Bay. These units will be in a separate development on the right abutment of Whitesand Dam.

The economic analysis presented in this part is based on these units with the exception of the third 750 kW turbine to supply energy to Southend and Brabant Lake. This unit was excluded owing to the uncertainty as to its date of commissioning. The timing is highly dependant upon the rate of acceptance of the hybrid heating system. It also relates to the implementation of new mine developments to utilize the load from the initial 750 kW mine unit. It is possible that excess capacity may be available from this unit to meet increasing community load. Not including this later unit addition will result in slightly higher projected average energy costs than if it was included in the evalution. When evaluating the turbines supplying the community of Southend, it has been assumed that the energy supplied in 1992, the year in which the first two community units will be fully utilized with respect to demand, will be supplied equally by the units for the remainder of the economic life of each. The economic life of a small hydro-electric development such as this is assumed to be 35 years.

5.2 ALTERNATIVE HYDRO-ELECTRIC SITES

As discussed in Section 4.1, the only feasible alternative site for providing hydro-electric power to the load centres is Otter Rapids. Apart from data obtained during a site visit, the only information available is on the 1:50,000 topographic map of the area. Due to the lack of data, it is only possible to prepare an "order of magnitude" estimate using a manual (ref.13) prepared for the Canadian Electrical Association by Shawinigan Consultants. In preparing the estimate it was assumed that the foundation for the concrete dam is bedrock. It was also assumed that the intakes and powerhouse would be a combined structure. To eliminate

the need for cofferdams for the construction of the 3 x 1000 kW units to be installed at a later date, it was assumed that the intakes and part of the powerhouse substructure would be built at the time of constructing the initial development.

The cost of an initial 2 x 750 kW development at this site is estimated to be $ 18,970,000. The 3 x 1000 kW extension is estimated to cost $10,020,000. Costs are in 1984 dollars. The breakdown of these estimates are presented in Appendix D.

5.3 WHITESAND DAM

5.3.1 Cost Estimates

The available information for Whitesand Dam is sufficient to enable more detailed and accurate cost estimates to be prepared. The existence of the dam at this site also eliminates many of the uncertainties that would otherwise have to be allowed for when preparing the estimates. The quantities were based on the layouts shown in Part 4 and preliminary design calculations. Costs were determined only after a review of in-house data for northern construction costs.

The cost estimates were prepared using the following groupings:

1) Unit Direct Costs

A file of basic unit direct costs applicable for hydro construction in northern regions provided the basis for determining these costs. Costs for the Whitesand Project were selected by applying a percentage adjustment to these figures based on actual working conditions. Suitable factors were applied to these costs to allow for unmeasured items.

2) Indirect Cost Allowances

These items are extremely variable when expressed as a percentage of the direct cost. Where possible, actual cost estimates were prepared for the following:

- on site construction facilities and services which are a function of the type of construction.
- supervisory cost which is related to the quality and availability of the local labour force.
- on site accommodation
- transportation and communication.

The costs of an initial 750 kW and an initial 2 x 750 kW development are estimated to be $5,440,000 and $7,560,000 respectively. The cost of the 3 x 1000 kW addition is estimated to be $ 10,920,000. These costs, in 1984 dollars, are summarized on Table 5.1 and a detailed breakdown of these costs is presented in Appendix D. It can be seen that a hydro-electric development at Whitesand is more economical than one at Otter Rapids.

TABLE 5.1
SUMMARY OF CAPITAL COSTS FOR WHITESAND DAM

	Initial 750 kW Unit	Initial 2 x 750 kW Units	3 x 1000 kW Addition
Access to site*	850,000	850,000	250,000
Intake, penstock and powerhouse	1,020,000	1,420,000	2,607,000
Mechanical equipment	797,000	1,440,000	2,484,000
Electrical equipment	128,000	246,000	508,000
Contingency	327,000	425,000	579,000
Indirect construction costs	1,103,000	1,548,000	2,270,000
Construction camp	300,000	400,000	500,000
Engineering design and supervision	550,000	750,000	1,100,000
Additional studies	53,000	53,000	-
Interest during construction	312,000	428,000	622,000
TOTAL	5,440,000	$ 7,560,000	$10,920,000

* Access for initial installations assumed to be by winter road from Southend. There will be no cost item for this road for the addition as it is assumed that this road will be maintained to allow access to the site after construction.

5.3.2 Schedule

The proposed construction schedule for the initial 2 x 750 kW development is shown on Figure 5.1. Since the intake and penstock has been sized for two units, they would be constructed to accommodate both turbine units regardless of whether a second unit was being installed at that time. Although there would be a reduction in the time required to construct the powerhouse, the construction schedule and overall duration of construction would not be significantly different if only one unit was installed initially.

We understand that the existing diesel generating plant at Southend requires a major upgrading in the very near future. The date for commissioning the proposed hydro-electric development at Whitesand Dam has been set at mid-1986. This is the earliest date of commissioning that can be achieved and is based on the fabrication and delivery time for the recommended Turbogen turbines. It should be noted that to achieve this date of commissioning, a decision to proceed with this project must be made very early in 1985 so that the turbine or turbines can be transported over the winter access road in early 1986. The proposed date of commissioning the development is also in line with the current projected date to start operating the proposed gold mine in the Star Lake/Waddy Lake area.

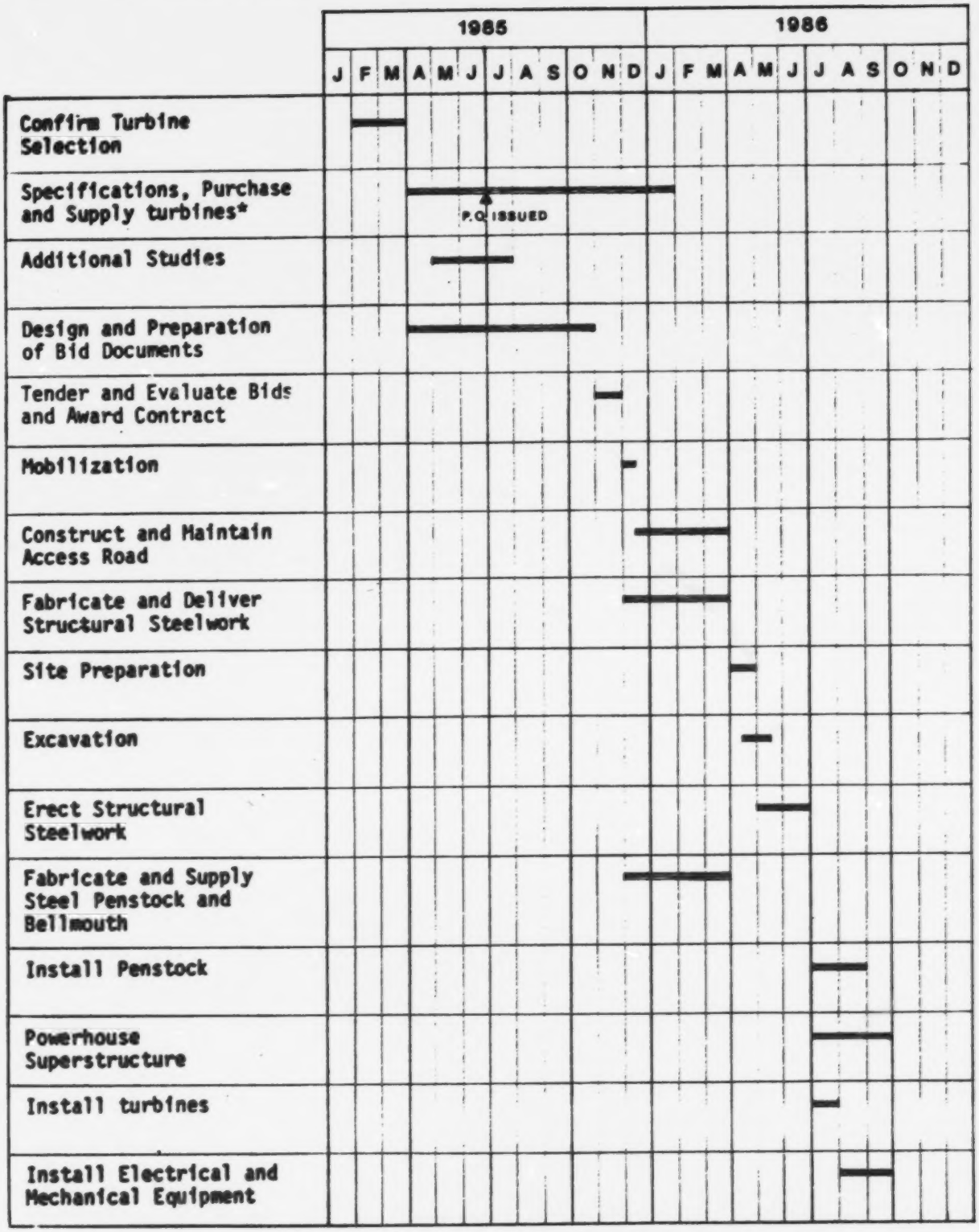
If the Kaplan or Ossberger units are preferred, our preliminary information indicates that these turbines would not be available for delivery during the 1985/86 winter resulting in a one year delay in commissioning the development.

The schedule for the 3 x 1000 kW addition would be similar to that for the initial units shown on Figure 5.1

As the dam already exists and the proposed developments will have a negligible effect on the present releases from Reindeer Lake, an environment impact assessment will probably only have to consider the effect of the proposed winter access road and the construction activities. The study should not be extensive and therefore should not affect the schedule.

5.4 UNIT COSTS

To be effective, a hydro-electric development must be capable of displacing the existing method of generating electricity using a diesel generator and producing heat through the use of oil furnaces. For this preliminary evaluation we have assumed that the initial development contains 2 x 750 kW turbines with one unit dedicated to Southend and one to the proposed gold mine. The evaluation then assumes the addition of


1985
1986
J F M A M J J A S O N D J F M A M J J A S O N D
Confirm Turbine Selection
Specifications, Purchase and Supply turbines*
P.O. ISSUED
Additional Studies
Design and Preparation of Bid Documents
Tender and Evaluate Bids and Award Contract
Mobilization
Construct and Maintain Access Road
Fabricate and Deliver Structural Steelwork
Site Preparation
Excavation
Erect Structural Steelwork
Fabricate and Supply Steel Penstock and Bellmouth
Install Penstock
Powerhouse Superstructure
Install turbines
Install Electrical and Mechanical Equipment

* If the selected turbines are not the Turbogen units, the schedule would have to be displaced one year to allow for delivery over the winter road in early 1987.

FIGURE 5.1
PROPOSED SCHEDULE FOR INITIAL 2 X 750 kW INSTALLATION

another 750 kW unit two years later to meet the projected peak load. Since the transmission lines were excluded from the scope of this study, the costs do not include transmission facilities beyond the main transformers.

Electricity can be produced by a diesel generator at a rate of 3.37 kWhr/litre. Heat is produced more efficiently: 1 litre of heating oil is equivalent to 7.86 kWhr of electricity. Therefore, the cost of energy from a hydro-electric plant serving a heat load must be less than half of that supplying a normal electric load.

If the energy from the proposed development at Whitesand Dam is to be used to supply heat through the hybrid heating system as well as the normal electric load, then the weighted cost of energy must be determined. This cost takes into account the equivalent values of fuel oil and heating oil as well as the ratio of normal electrical load to the heating load and operating costs for the diesel plant.

Using data supplied by North Sask Electric for 1983, the cost of fuel to produce electricity at Southend was approximately 11.1 cents per kWhr and the cost of operating and maintaining the diesel plant 7.7 cents per kWhr. This gives a total cost of supplying electricity of 18.8 cents per kWhr in 1983 or 19.7 cents per kWhr in 1984 dollars. Since one of the two initial 750 kW units will be supplying the communities of Southend and Brabant Lake, the ratio of the heat load to the total electric load has to be determined. An equivalent heat load of 1,045 MWhrs per annum would have been supplied in 1982 while the total electric load would have been 4,830 MWhrs, including the mine. Using the ratio of these loads of 0.21 and the equivalent value of heating oil, the weighted cost of energy is estimated to be 17.1 cents per kWhr in 1984 dollars.

If no value is assigned to the capacity of the hydro-electric development, then to be cost effective, the cost of providing electricity must not exceed 17.1 cents per kWhr for the initial 2 x 750 kW installation and 19.7 cents per kWhr for the 3 x 1000 kW addition.

In order to determine the cost of power supplied by a hydro-electric plant at Whitesand Dam, the discounted sum of the energy supplied and the present value of the cost of the plant, including any additions and operating costs, have to be determined. Effective discount rates of 4%, 6% and 8% were used.

Based on the projected load forecast, the initial 2 X 750 kW units in the initial development would be followed by a 750 kW unit in 1988. By 1992, all three units would be fully utilized in terms of demand. It was assumed that the energy supplied to Southend and Brabant Lake in 1988, some 4,560 MWhr would continue to be supplied equally by the two units for the duration of the assumed life of each. In the absence of other information, the third unit supplying energy to the gold mine is assumed to have a load factor of 70 percent as discussed in Part 3, for the initial 15 years reducing to 40 percent for the remaining 20 years. In the event that the mine load ceases within the life of the unit, the turbine could be used to supply the increasing energy demands of Southend.

It was also assumed that the 3 x 1000 kW addition to supply energy to the proposed graphite mine at Deep Bay would also have a load factor of 70 percent for the initial 15 years reducing to 40 percent for the remaining 20 years. As no information was available for this mine, the unit costs should be considered to be speculative at best.

The discounted sum of the energy produced over the life of the units is presented on Table 5.2.

TABLE 5.2
SUMMARY OF UNIT COSTS

	Initial 2 x 750 kW + 1 X 750 kW Development			3 x 1000 kW Addition		
	4%	6%	8%	4%	6%	8%
Discounted Sum of Energy (MWhr)	141,000	109,900	88,500	246,000	198,000	164,700
Present Value of Cost (1984 $ x 1000)	15,660	14,750	14,090	13,910	13,240	12,790
Unit Cost (cents/kWhr)	11.1	13.4	15.9	5.6	6.7	7.8

When calculating the present value of the cost of the hydro-electric plants, consideration must be given to the assumed 35 year life of the installation. To do this the operating and maintenance costs incurred over the life of the plants were used to determine the net present cost. Included with these costs are interim replacement of parts, insurance, winter road maintenance, administration and general expenses.

Comparing the unit costs presented in Table 5.2 with the weighted cost of energy of 17.1 cents/kWhr for the 2 x 750 kW installation and the cost of diesel generation of 18.8 cents/kWhr for the 3 x 1000 kW installation, it can be seen that both developments are cost effective.

REFERENCES

Following is a list of the references annotated in this report.

1) Personal communication; Mr. Dave Francis, General Manager, Saskatchewan Minerals Development Corporation, Saskatoon; July 1984.

2) Personal communication; Dr. Beck, Saskatchewan Department of Energy and Mines, Regina; July 1984.

3) "Remote Saskatchewan Energy Overview Study" by Underwood McLellan Ltd., Saskatoon; Energy Mines and Resources Canada, March 1983.

4) Personal communication; Bella Cook, Office of the Northern Hamlet of Southend; July 1984.

5) "Northern Saskatchewan Community Directory" Extension Services Branch, Department of Northern Saskatchewan; August 1983.

6) "Northern Saskatchewan Community Directory" Extension Services Branch, Department of Northern Saskatchewan; August 1981.

7) Personal communication; Pat Varls, Forecasting and Economic Analysis, Saskatchewan Power Corporation; August 1984.

8) Personal communication; Wally Gillard and Roy Luhning, Customer Advisory Services, Saskatchewan Power Corporation; August 1984.

9) Personal communication; John Cairns, Senior Mining Engineers, Saskatchewan Minerals Development Corporation, Saskatoon; August 1984.

10) "Churchill River Hydrological Review" by Crippen Acres, Regina; Saskatchewan Power Corporation; August 1984.

11) "Roddickton Mini-Hydro Development" Energy, Mines and Resources Canada; 1983.

12) "Mini Hydro Installations in the Province of Ontario" by R.A. Everdell and A. Mohino; Small Hydro-Power and Fluid Machinery, The American Society of Mechanical Engineers.

13) "Methodology for the Design and Costing of Small Hydro Plants: Project 162 G 323" by Shawinigan-Lavalin Inc.; Canadian Electrical Association, Montreal, Quebec; October 1983.

APPENDIX A - TERMS OF REFERENCE

SASKATCHEWAN POWER CORPORATION

2025 Victoria Avenue
Regina, Saskatchewan
S4P 0S1
1984 May 01

FENNELL-COCHRANE-LAVALIN INC.
300 - 3303 Hillsdale
REGINA, Saskatchewan
S4S 6W9

Attention: Mr. T. C. Cochrane, President

Subject: Power Supply Study - Whitesand Control Dam

Gentlemen:

You are invited to consider the tendering of your services to SPC to undertake the study and the review as detailed in the attached document.

In reply to this invitation, please detail your expertise and the resources that you have available or have access to in undertaking such a study. The study is to be completed no later than 1984 September 15.

An acceptance of the total cost of the study not to exceed $40 000 and the acceptability of the indicated schedule completion date is also requested. Replies will be considered up to and including 1984 May 18.

Prior to this closing date, arrangements may be made at your request for presentations and/or for further discussions at our Regina office to address the contents of the attached proposal.

To obtain further information and to arrange for a suitable time for discussion or your presentation, please contact me at the above address, telephone (306) 566-2989.

Yours truly,

E. K. Overgaard

E. K. Overgaard
Chief, Hydro Development Planning
Generation Planning

EKO/ksz
Attachment

Saskatchewan Power Corporation

Scope of Work and General Conditions for

Proposed Study for Hydro-Electric Installation at Whitesand Dam on the Reindeer River at the Outlet of Reindeer Lake

1. Scope of Work

The work includes a review of the literature on recent innovations relative to the supply of electric power to a community from a proposed small hydro plant at Whitesand Dam on the Reindeer River, at the outlet of Reindeer Lake. The study includes the selection of suitable works and the optimum site arrangement taking into account the access, the topographic, and the geotechnical considerations, materials availability, etc. for up to 500 kW of power and associated energy to meet the current needs of the Southend community. Transmission line requirements beyond the generator control package are not included.

The study includes the expansion of the works to meet foreseeable mining load requirements at two locations, one requiring up to one MW capacity and the other up to three MW capacity.

The results of the study will be a proposal which shall show how the single loads and the combined load may best be supplied at minimum overall site costs, and how to provide for possible future expansion of up to double the magnitude of each of the individual loads. The study also requires the identification of the additional hydrologic,

topographic, and geologic work requirements plus a work schedule and estimated detail costs of the work which will permit the design and construction of the consultant's study proposal for the initial installation. Nominal consideration shall be given to the potential salvage of units if flooding from a downstream development were to occur.

A synopsis of a community profile covering the socio-economic, energy use and electrical demand forecast is required. The consultant's report may make use of SPC's data, Churchill River Study data, and environmental staff interviews to provide the required synopsis.

A synopsis of the available Churchill River Hydrological Review is required. Also, a summary of estimated costs from alternative hydro sources for this community is required. The purpose of these synopses is to assist in justifying the study and the continuance of this work.

2. General Conditions

a) Water Supply

Water supply is to be assumed adequate at all times, although forebay and tailrace fluctuation within approximate limits is expected. No advantage is deemed practical to use the existing dam facilities because of the need to maintain minimum interference with the removal and placement of stoplogs and the egress of flood waters from the reservoir upstream of the dam.

b) Site Review

For the purpose of site examination, no drilling is envisaged at this stage. Visual examination of the site, available contour maps, and general knowledge of the materials sources are deemed adequate for preliminary purposes.

c) Location of Study

The study is to be carried out by the consultant who will have an office located in Saskatchewan where the bulk of the work is to be done. The consultant shall provide an estimate of the percentage of work that will be undertaken by Saskatchewan residents. Our definition of a Saskatchewan resident is a person who holds a current Saskatchewan Hospitalization card.

d) Work Schedule and Progress Reports

The consultant will provide a detailed breakdown of the work schedule which will include provision for monthly progress reports summarizing the status of the study. These progress reports shall be available by the 26th day of each month.

e) Study Project Liaison

Liaison will be established between the consultant's study representative and the SPC appointed Study Manager. Any questions on the hydrology, site project arrangements, provision for extension, etc. shall be resolved to the satisfaction of the Study Manager. The Study Manager will act as liaison with the

Study Committee consisting of representatives of the community, EM&R, and SPC. Joint meetings between the consultant and one or more Study Committee representatives are to be held monthly in Regina at a mutually agreeable time. Provision must be made for a one-day presentation of the study results to the Southend community after completion of the study.

f) Cost Estimates.

Cost estimates are to be in sufficient detail to show the breakdown of costs for water supply, foundations, superstructure, and plant works.

g) Design and Construction Schedule

A potential schedule for implementing the works is required, making allowance for any required additional investigations and studies.

h) Reports

An interim report is required within 30 days of study completion to summarize the findings, conclusions, and recommendations. Five copies of this report will be provided for circulation for review and comment by SPC, EM&R and others. After incorporating any requested changes, the report will be finalized within 60 days of study completion and fifteen copies made available to SPC for distribution.

i) Payment of Invoices

Invoices for the study shall be submitted monthly to SPC for the proportion of the work completed and according to the accepted work schedule. Reasons for the non-completion of scheduled work must be documented and a revised schedule submitted. Failure to meet the revised schedule on any work will be cause for withholding of payments until the work schedule is met.

Invoices will be paid promptly, normally within four weeks after receipt of invoice.

Saskatchewan Power Corporation

Generation Planning

1984 April 18

APPENDIX B - GEOLOGICAL OVERVIEW OF WHITESAND DAM

J D MOLLARD AND ASSOCIATES LIMITED

CONSULTING CIVIL ENGINEERS AND ENGINEERING GEOLOGISTS

Telephones 352-8811 352-8855
Area Code 306

510 Avord Tower, 2002 Victoria Ave
Regina · Saskatchewan · Canada
S4P 0R7

June 26, 1984

Mr. Roger Kitchin, P.Eng.
Fennell Cochrane Lavalin Inc.
Suite 300 - 3303 Hillsdale Street
Regina, Saskatchewan
S4S 6W9

Subject: Interim report covering an airphoto and map study of the Whitesand Dam area and alternative access routes
June 26, 1984

Dear Mr. Kitchin:

Background

I have examined all of the airphotos and maps that I could locate, including a report that I coauthored with J.W. Libby and J.E. Balzer, dated November 27, 1970. That report was prepared for SPC, attention of Mr. E.B. Campbell. I enclose a copy of the table of contents and summary of that report (Appendix A). Photos 31, 32, 33 and 34 in the 1970 report, and shown as Figures 8 and 9 in this report, show aerial oblique colour snapshots that I took of Whitesand Dam area from a fixed-wing aircraft. The photos show the main structures and the operator's house. I understand that the operator now lives in Southend. One can tell from these photos that large nearby eskers -- which I have identified on high-altitude, small-scale airphotos -- contain a high content of sand, as evidenced by the sandy bedforms in Photo 31 and the sandy foreshore and sandy island shown in Photo 32. A contour map of the Whitesand Dam area, with a scale of 1:12,000 and a contour interval of 10 feet below elevation 1200 feet, was prepared for SPC in May 1973 (Figure 1).

Surficial geology

Glacial Lake Agassiz covers the entire study area, reaching on elevation of ±1250 feet (Figure 2).

The east-west trending Cree Lake moraine, the largest end moraine in northern Saskatchewan, crosses the Reindeer River about 5 miles south of the Whitesand Dam (Figure 3). The southern glacier margin lay along this long end moraine between 10,000 and 9000 years ago, depositing mainly sand and gravel along with some till. Glacial Lake Agassiz followed the south

side of this end moraine, reaching elevations of 1200 to 1250 feet, well above the forebay elevation of 1103 to 1106 feet and the tailwater elevation of around 1078 feet as shown on topographic maps of the area prepared in 1973 (Figure 1). As a result, pockets of glacial lake clay, silt and fine sand overlie till; and in places the lacustrine sediments overlie bedrock.

Large southwest-northeast trending eskers cross the Reindeer River in the immediate vicinity of the dam (Figures 3,4,5,6,7). These eskers, often segmented, are expected to have a high content of sorted sand. However, they will also contain some gravel and boulders. I have marked places on the airphotos with X's. They are locations for you to field check if the opportunity exists.

In general overburden materials in vicinity of the Whitesand Dam are sandy eskers, relatively coarse ablation and basal tills, glacial lake fine sand, silt and clay, and frozen and unfrozen peat on poorly drained depressions. In these poorly drained depressions, the peat and muck contains permafrost where the peat surface is elevated a metre or two and is dry at the surface. Thaw ponds (thermokarst) containing fen peat and fen vegetation occur within the peatland, giving the landscape a moth-eaten appearance from the air.

Bedrock geology

In the high level, small scale airphotos the bedrock is evident only where there are recent burns. In these places I can see the rock structure (foliation and fractures). The airphotos are much too small in scale and the tree cover is much too dense to see small rock outcrops in the immediate vicinity of the Whitesand Dam. I expect the dam was built on bedrock, and Dr. W.G.Q. Johnston has mapped a striated bedrock surface in vicinity of the Whitesand Dam (Figure 4).

Careful field study and evaluation of alternative siphon-penstock sites is necessary. In addition, ground photos of rock outcrops would be useful in follow-up office studies.

The overburden deposits may be so irregular and the bedrock so uneven that several geophysical traverses are needed to properly define the bedrock surface.

There are several major faults west of the site, and there is a northeast-southwest fault cutting through the middle of Marchand Lake (Figures 5 and 6).

The power generating unit should be founded on solid bedrock. Glacial lake silts and clays in the area are likely to be weak and permafrost can be expected in dry peatlands.

Mr. Roger Kitchin . . . .

Borrow sources

A large area of sand and gravel, till and surface boulders are anticipated in the ridge west of Whitesand Dam and huge sandy eskers east of the sand (Figures 5,6,7). Finding coarse gravel for concrete may be a problem but detailed field reconnaissance of the large deposits shown should identify sufficient coarse aggregate for the proposed structures. The eskers may contain shale since the bottom of Deep Bay -- an old (1×10^8 years) meteorite crater that is over 800 feet deep -- is floored with Upper Cretaceous shale that was driven down into the Precambrian basement rocks by the meteorite impact. If it is possible during reconnaissance the sand and gravel sources should be checked for soft shale particles. This occurrence is an oddity because this far north in the Canadian Shield there is no shale bedrock, south of La Ronge being the closest source of Cretaceous shales, some 100 or more air miles to the southwest.

Alternative access road locations and terrain conditions

I have located alternative access road routes from Highway 102. The routes look fair considering that there is a great deal of steep rugged bedrock (rock cliffs and jagged rock), steep slopes, narrow beaches along rock-walled lakes, surficial clay and peat, and permafrost in poorly drained depressions containing peat deposits.

If you get an opportunity to fly over the indicated access routes and take aerial pictures I would like to view them. There is relatively little sand and gravel along the selected routes. Most of it lies at the north end or in the general vicinity of the Whitesand Dam. (Notice sections of route marked steep or tight or bedrock on Figures 5 and 6.)

Possible alternatives are a winter haul road over frozen ground or a haul road over the ice south from Southend -- i.e. if the ice thickness is great enough to carry the load.

Reconnaissance field investigations

Existing and future seepages around and through the dam are a concern and one should look for these in the field. If you can retrieve any samples of coarse gravel, sand or bedrock, I would very much like to see them. The bedrock at Whitesand Dam is likely to be migmatites, granitic gneisses, hornblend gneiss and possibly some granitic rock. To the north of a fault through Marchand Lake the rock type changes to "Kisseynew gneisses," which are metamorphosed Precambrian greywacke.

Mr. Roger Kitchin . . . .

Summary and conclusions

1. The dam appears to be founded on rock and so should the power generating unit.

2. It is necessary to reconnoitre the alternative penstock intake sites, penstock routes and power generating unit sites for bedrock and signs of seepages.

3. As an alternative to an elevated system arrangement, I think a small unlined tunnel in hard rock should be considered and the cost evaluated.

4. There appears to be large sources of sand and boulders but the gravel at them is likely to occur in isolated pockets that are covered by dense forest.

5. I have obtained recent topographic maps and these should provide an idea of the head that is available for development.

6. Depending on the tailrace location there could be some degradation of sands downstream of the generating unit.

7. I have located alternative access road routes. These routes should be inspected from aerial reconnaissance and, if an access road is a feasible alternative, the route should be re-photographed at a suitable scale (say, 1:12,000). The terrain should then be re-typed from the airphotos. The existing alternatives mainly overlie thin, discontinuous glacial lake fine sands, silts and clays over a gritty, boulder-rich till. There are short segments of bedrock.

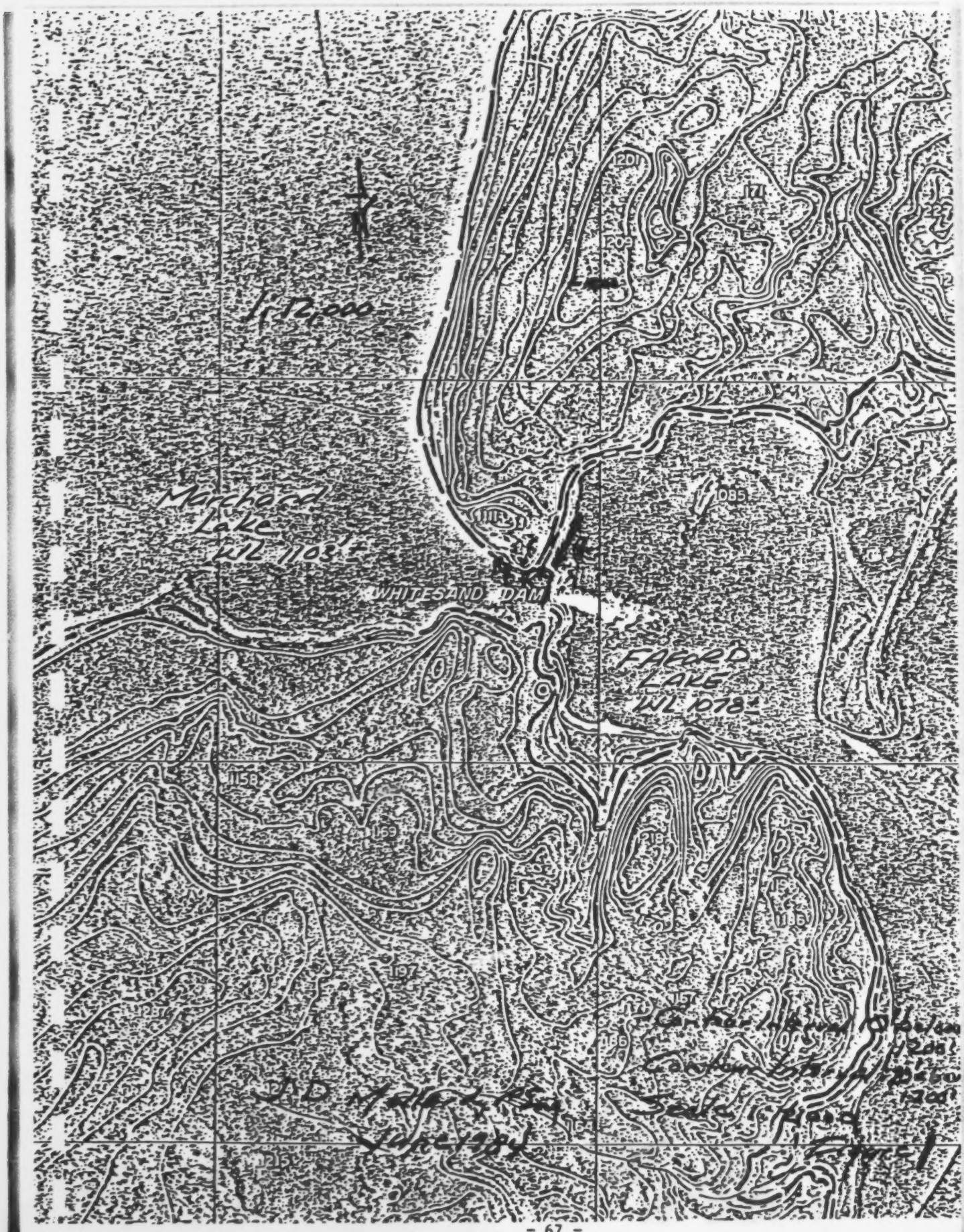

1"=2,000'
Marchand Lake WL 1103'±
WHITESAND DAM
FARRD LAKE WL 1078'±
JD MINE ROAD

Figure 2
J.D. Mollard, 1984
June 1984
After Teller et al

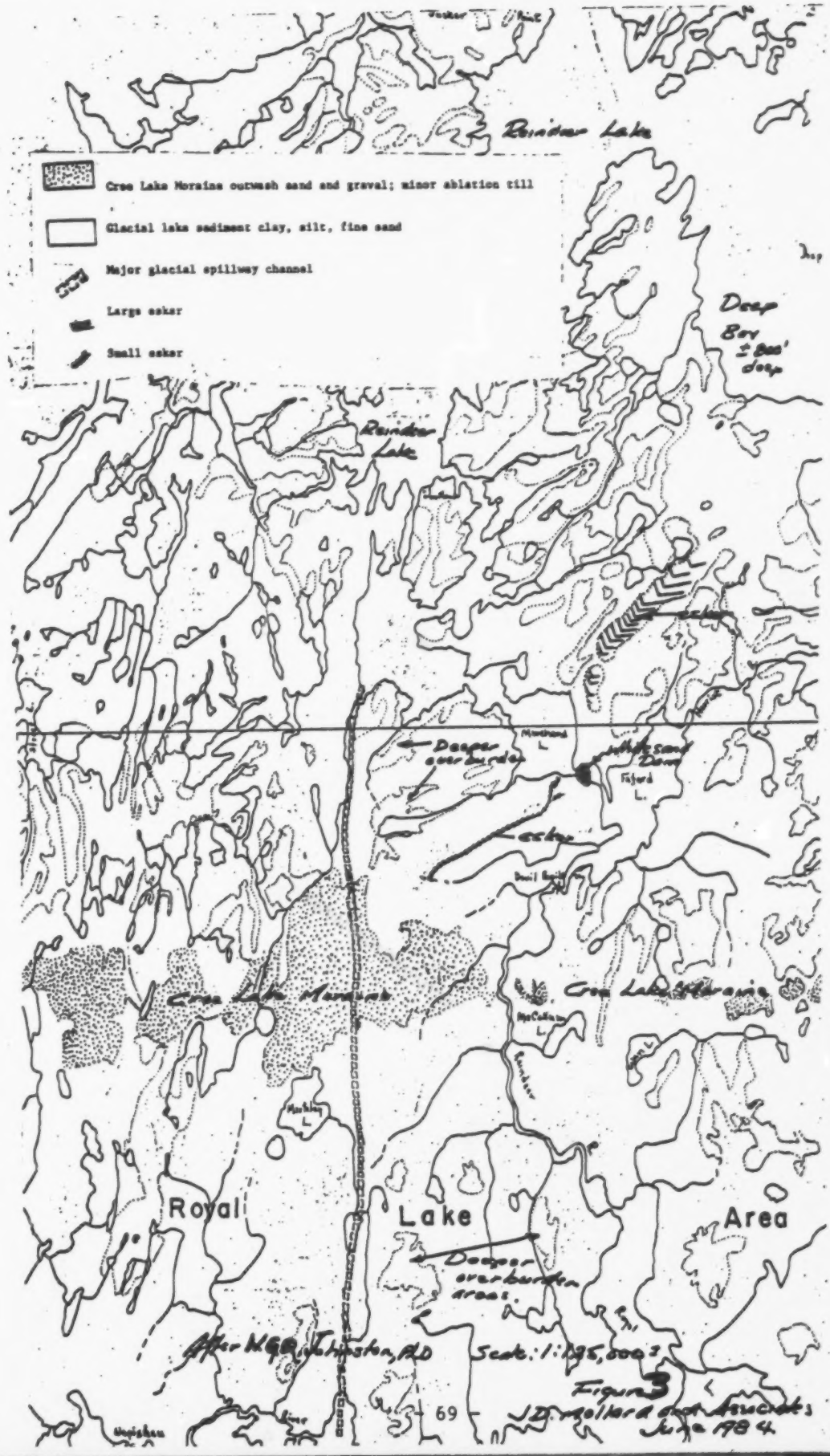


Figure 3

J.D. Mollard and Associates June 1984

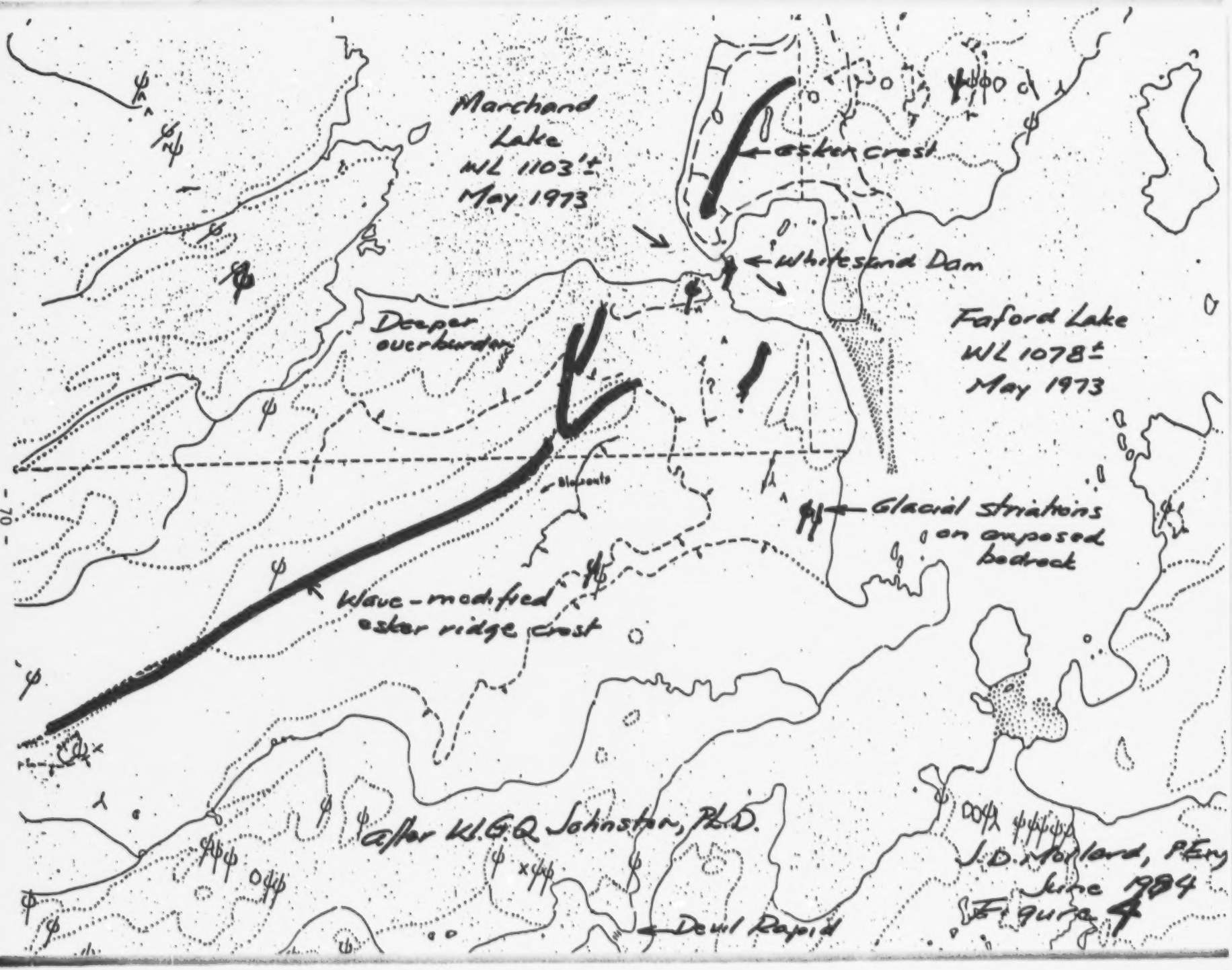
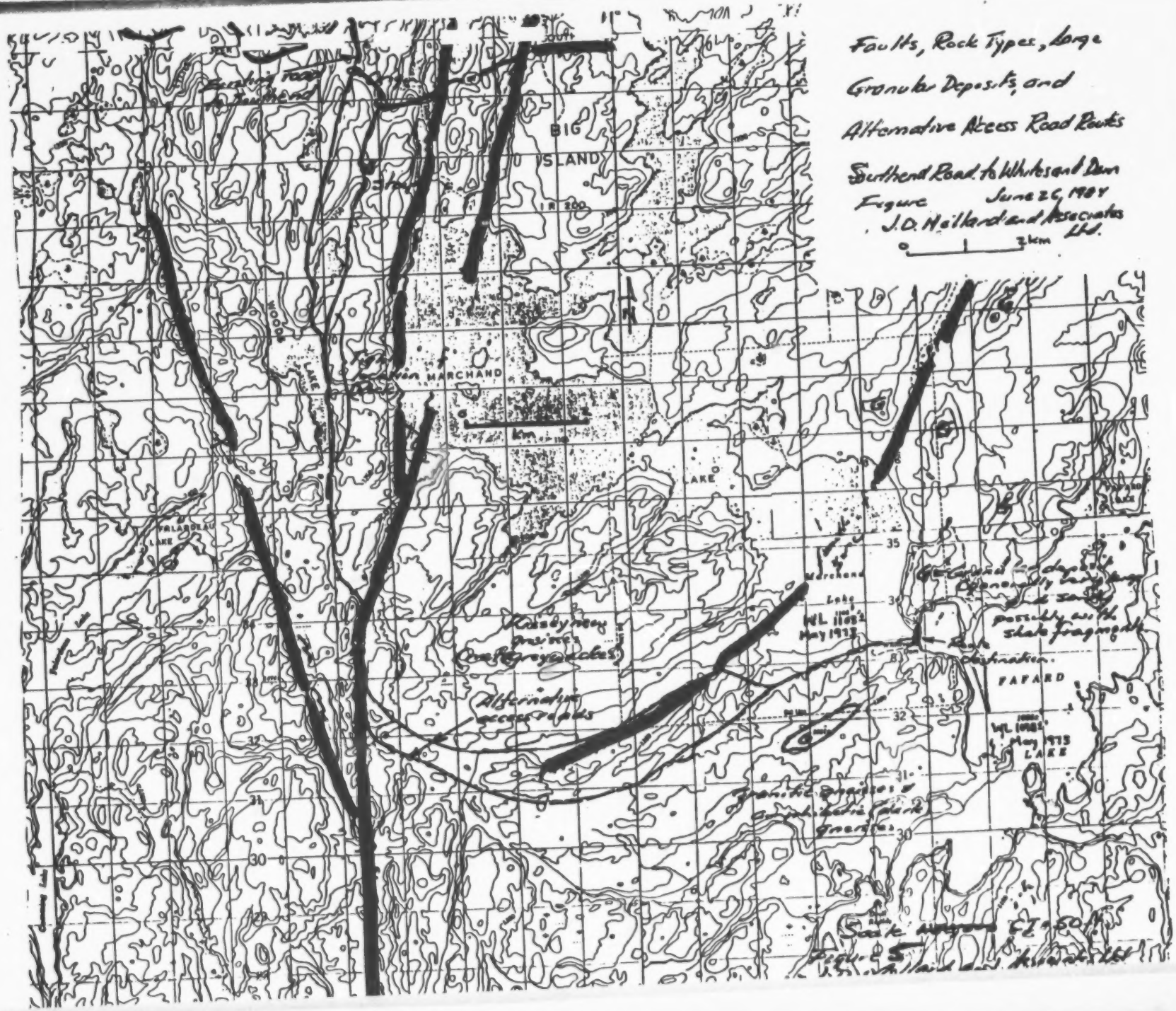
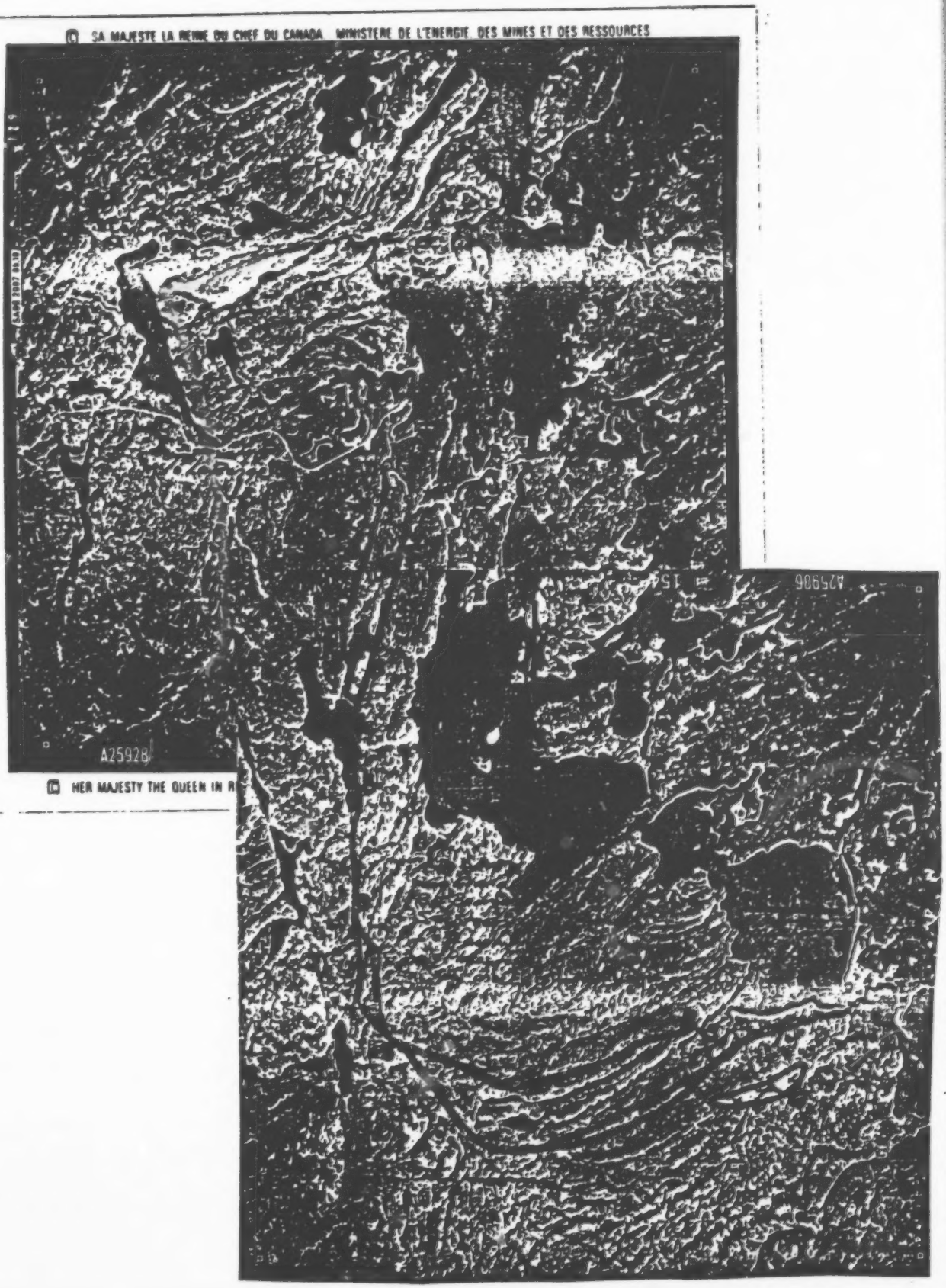

Marchand Lake WL 1103'± May 1973
esker crest
Whitestand Dam
Deeper overburden
Faford Lake WL 1078± May 1973
Glacial striations on exposed bedrock
Wave-modified esker ridge crest
after W.G.Q. Johnston, P.L.S.
J.D. Morland, P.Eng. June 1984
Devil Rapids

Figure 4


Faults, Rock Types, Borrow
Granular Deposits, and
Alternative Access Road Routes
Southend Road to Whiteshell Dam
Figure
June 26, 1984
J.D. Mollard and Associates Ltd.
0 1 2km
BIG
ISLAND
LAKE
MARCHAND
WOOD
LAKE
FALARDEAU
LAKE
Alternative access routes
Granite Gneiss
Granite Gneiss
Granite Gneiss


© SA MAJESTE LA REINE DU CHEF DU CANADA MINISTERE DE L'ENERGIE, DES MINES ET DES RESSOURCES
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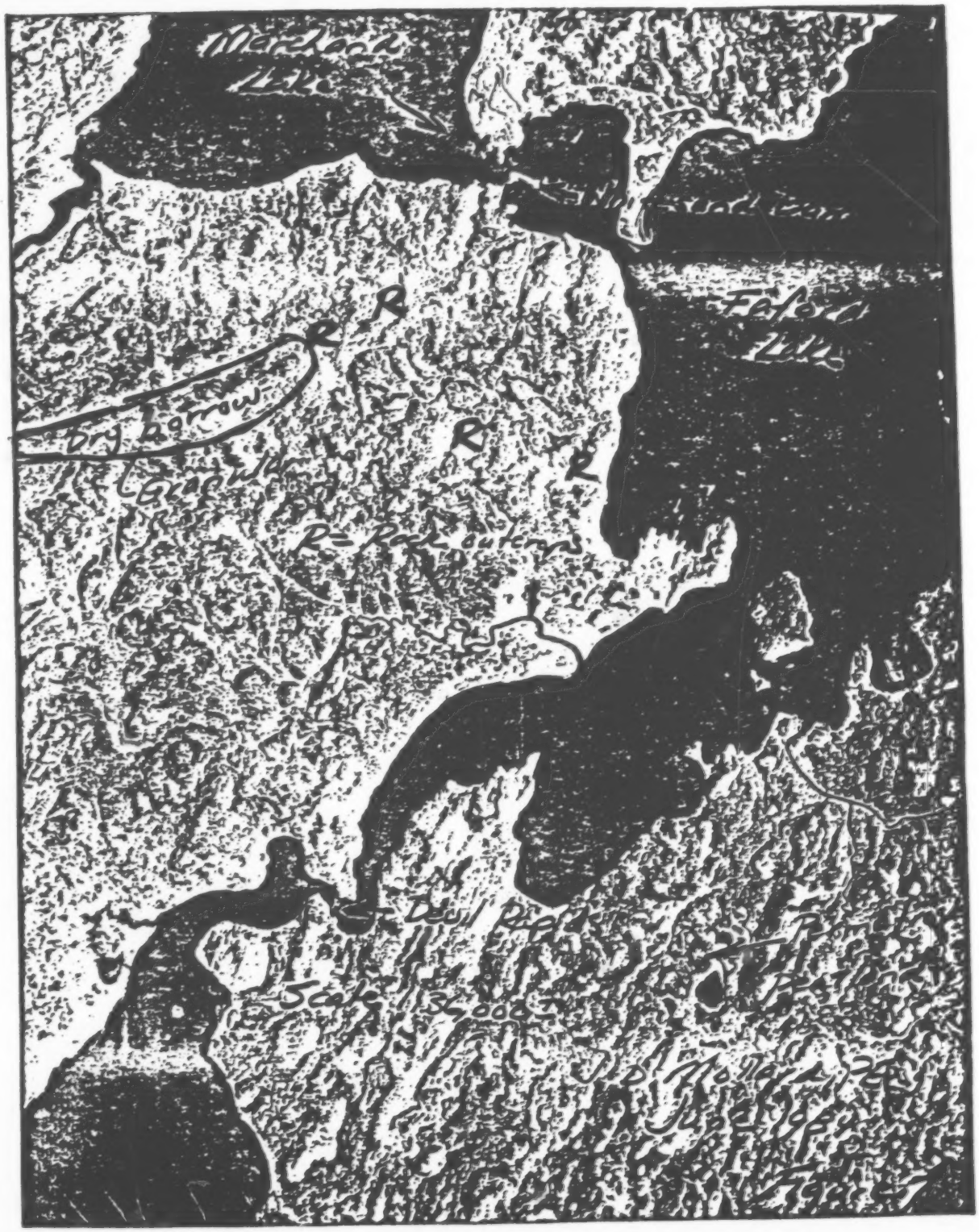
© HER MAJESTY THE QUEEN IN R
A25906


Dry Borrow
R
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R

APPENDIX C - HYDROLOGICAL DATA

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1929	173.000	172.000	165.600	159.400	157.500	172.667	233.500	264.600	299.250	288.000	282.600	293.000	221.760
1930	278.400	267.000	260.750	248.250	279.750	345.500	373.750	342.400	312.750	322.000	293.000	288.800	301.029
1931	294.250	271.750	265.600	255.750	304.600	383.500	460.250	481.800	469.500	464.250	465.000	463.000	381.604
1932	441.800	419.000	400.900	379.500	418.600	549.500	619.000	643.500	640.500	608.200	587.500	541.000	520.675
1933	497.800	475.250	436.750	406.600	416.750	509.000	586.000	572.500	511.000	452.400	423.250	396.800	473.674
1934	368.750	358.500	346.000	315.200	356.750	477.250	553.000	598.250	587.800	573.500	558.000	530.200	468.600
1935	486.000	450.250	422.600	385.500	438.000	454.000	427.500	424.000	407.800	389.250	427.500	409.400	426.816
1936	377.250	386.750	387.400	321.500	311.400	370.250	423.000	462.800	446.000	373.000	365.200	340.250	380.400
1937	330.600	337.500	345.250	290.500	265.000	310.750	333.500	246.000	248.250	216.200	218.000	216.250	278.983
1938	214.600	214.750	210.000	207.500	218.800	244.000	149.000	128.840	138.733	189.032	219.533	228.903	196.974
1939	245.774	241.357	234.806	233.233	207.129	297.200	308.581	428.645	449.067	407.323	374.700	360.742	315.713
1940	346.839	331.414	304.839	286.300	263.581	288.866	264.516	257.064	242.433	268.387	280.667	244.548	281.621
1941	250.129	247.786	240.806	234.033	196.645	205.500	182.161	226.355	212.500	236.000	239.533	248.032	226.623
1942	266.064	266.964	268.161	246.733	245.097	202.833	147.000	190.516	246.767	322.193	295.833	310.839	250.750
1943	308.258	328.000	336.645	307.600	238.484	189.833	160.677	166.226	205.733	233.935	217.500	220.645	242.711
1944	232.387	253.345	250.968	200.867	178.032	146.200	173.032	151.516	196.967	347.323	306.967	305.032	228.553
1945	300.290	293.071	286.581	285.600	293.742	289.300	291.645	292.613	295.300	293.581	294.866	295.903	292.709
1946	291.258	285.643	279.226	294.467	287.742	298.000	307.387	548.097	844.900	270.484	226.667	274.387	350.688
1947	272.968	270.286	267.258	264.667	231.871	632.500	804.677	289.355	231.600	83.142	219.483	345.839	326.137
1948	437.258	429.103	414.419	405.000	403.935	660.700	771.387	481.032	289.467	290.968	291.833	291.548	430.554
1949	289.871	287.714	284.290	281.733	289.516	308.567	718.161	788.258	721.400	420.806	412.033	413.193	434.629
1950	408.290	402.964	394.387	387.300	392.645	415.267	417.258	416.484	363.533	294.935	296.400	296.903	373.864
1951	296.129	310.786	310.548	305.990	312.613	328.833	418.903	420.742	414.433	313.161	305.967	301.548	336.630
1952	302.709	340.414	333.903	287.500	270.839	263.733	135.484	119.516	121.500	144.323	213.700	214.968	229.049
1953	246.774	261.607	274.129	296.600	296.613	299.300	300.290	300.097	299.100	300.968	300.500	301.161	289.761
1954	299.903	297.321	295.226	290.967	291.323	298.300	321.839	512.097	395.000	293.387	290.667	250.097	319.677
1955	209.452	222.643	290.645	289.100	124.977	217.433	218.871	218.742	217.400	397.903	414.100	408.000	269.105
1956	400.935	395.000	387.226	378.866	260.484	220.200	171.484	130.358	175.933	170.194	187.000	206.065	256.979
1957	228.097	232.964	229.968	195.733	112.442	0.0	0.0	22.535	133.800	202.032	217.700	287.742	155.251
1958	286.000	282.500	279.548	277.300	282.161	289.400	292.839	292.193	293.267	293.806	293.000	292.968	287.915
1959	291.000	287.500	284.451	279.800	280.871	422.233	508.387	502.226	496.033	453.516	280.467	280.484	363.914
1960	277.581	274.655	270.935	211.067	220.516	390.300	688.645	640.871	617.667	445.968	298.933	272.839	384.164
1961	226.065	290.821	288.419	286.900	290.806	285.233	215.548	217.613	261.100	277.258	299.500	363.613	275.240
1962	400.581	413.428	407.516	400.500	340.935	306.433	316.742	379.645	374.833	344.032	315.333	353.032	362.750
1963	390.709	435.714	425.193	414.900	264.742	271.833	218.645	232.419	284.300	308.709	366.767	370.903	332.069
1964	415.871	413.310	445.516	416.400	328.451	212.733	241.194	294.871	416.300	384.935	384.100	383.258	361.411
1965	379.613	416.214	421.129	412.700	284.871	278.866	283.032	284.484	264.100	282.355	282.567	281.645	324.298
1966	330.226	343.714	412.709	353.233	321.742	288.233	255.710	257.355	257.366	330.613	285.267	294.193	310.863
1967	395.000	400.393	393.548	385.700	305.516	259.067	274.548	246.742	213.700	285.871	426.933	442.968	335.832
1968	502.451	550.931	522.161	503.567	420.097	398.333	373.000	401.097	383.933	375.677	389.267	439.548	438.338
1969	479.903	461.928	449.871	439.267	350.613	302.866	323.129	360.871	309.433	270.484	346.600	398.709	374.473
1970	443.935	441.464	455.613	454.933	395.097	290.433	48.353	0.0	0.0	24.577	63.207	142.332	229.995
1971	151.739	29.986	31.497	32.883	36.119	43.597	400.674	506.677	390.600	328.839	345.933	427.806	227.187
1972	465.968	479.000	477.258	475.267	325.355	304.967	311.613	312.258	313.433	311.613	327.400	427.032	377.597
1973	474.677	482.607	500.451	487.267	391.226	192.363	156.323	159.097	158.633	158.419	160.767	161.194	290.252
1974	193.774	256.464	310.484	334.000	221.613	376.667	246.903	286.355	327.833	216.484	217.733	219.581	267.324
1975	270.806	363.143	379.935	468.000	443.419	323.433	334.806	436.968	431.533	324.290	214.133	282.839	356.109
1976	367.323	381.586	406.258	314.033	264.839	260.800	216.710	305.323	660.967	626.774	433.600	433.097	389.275
1977	483.419	512.714	501.613	434.267	351.839	724.633	859.097	847.968	542.767	426.451	427.000	472.548	546.692
1978	538.387	524.750	484.226	454.600	391.484	292.100	207.484	213.387	402.533	541.677	433.467	431.290	409.615
1979	460.000	492.500	481.709	470.133	459.839	290.733	148.290	126.839	228.367	308.258	307.767	385.451	346.657
1980	420.548	474.965	482.419	434.800	314.355	403.300	410.548	449.323	396.600	389.516	387.900	447.323	417.632
1981	443.129	432.464	421.548	373.567	274.709	210.000	199.355	262.581	371.900	424.032	434.200	419.839	355.610
1982	403.000	383.000	333.000	254.000	119.000	34.000	0.0	69.000	70.000	164.000	376.000	449.000	221.167
MEANS	344.213	349.571	347.980	329.646	291.574	311.675	329.692	337.241	344.547	323.425	320.803	336.263	330.552

TABLE 7

OUTFLOWS FROM WHITESAND DAM AS RECORDED BY CRPC (M^3/S)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1929	173.000	172.000	165.600	159.400	157.500	172.667	233.500	264.600	299.250	288.000	282.600	293.000	221.760
1930	278.400	267.000	260.750	248.250	279.750	345.500	373.750	342.400	312.750	322.000	293.000	288.800	301.029
1931	294.250	271.750	265.600	255.750	304.600	383.500	460.250	481.800	469.500	464.250	465.000	463.000	391.604
1932	441.800	419.000	400.000	379.500	418.600	549.500	619.000	643.500	640.500	608.200	587.500	541.000	520.675
1933	497.800	475.250	436.750	406.600	416.750	509.000	586.000	572.500	511.000	452.400	423.250	396.800	473.674
1934	368.750	358.500	346.000	315.200	356.750	477.250	553.000	598.250	587.800	573.500	558.000	530.200	468.600
1935	486.000	450.250	422.600	385.500	438.000	454.000	427.500	424.000	407.800	389.250	427.500	409.400	426.816
1936	377.250	386.750	387.400	321.500	311.400	370.250	423.000	462.800	446.000	373.000	365.200	340.250	380.400
1937	330.600	337.500	345.250	280.500	265.000	310.750	333.500	246.000	248.250	216.200	218.000	216.250	278.983
1938	214.600	214.750	210.000	207.500	218.800	244.000	149.000	128.840	138.733	189.032	219.533	228.903	196.974
1939	245.774	241.357	234.806	233.233	207.129	297.200	308.581	428.645	449.067	407.323	374.700	360.742	315.713
1940	346.839	331.414	304.839	286.300	263.581	288.866	264.516	257.064	242.433	268.387	280.667	244.548	281.621
1941	250.129	247.786	240.806	234.033	196.645	205.500	182.161	226.355	212.500	236.000	239.533	248.032	226.623
1942	266.064	266.964	268.161	246.733	245.097	202.333	147.000	190.516	246.767	322.193	355.000	370.000	260.611
1943	363.594	392.307	408.355	368.438	270.613	208.705	175.112	181.804	227.196	260.950	241.231	245.114	278.618
1944	259.212	285.174	282.304	221.781	194.774	158.702	189.194	164.749	216.253	405.603	350.787	348.370	256.408
1945	342.519	333.692	325.830	325.541	336.619	329.119	331.972	333.161	336.475	334.330	335.888	337.146	333.524
1946	331.490	324.703	317.019	338.113	327.421	339.734	351.329	656.061	982.838	298.581	245.925	298.832	401.003
1947	297.270	294.236	290.826	267.925	248.069	649.917	805.200	305.924	246.769	98.271	239.499	369.710	344.468
1948	463.889	455.207	440.367	431.696	430.647	680.297	780.769	503.420	325.059	326.724	327.685	327.367	457.776
1949	325.503	323.114	319.330	316.514	325.118	345.250	793.212	869.985	787.462	448.887	438.483	439.752	477.717
1950	434.406	428.736	420.109	413.115	416.772	436.533	438.512	437.747	387.537	324.736	326.295	326.799	399.274
1951	325.987	343.731	343.991	339.110	345.957	362.700	442.860	444.872	438.117	346.019	339.248	335.004	367.299
1952	335.779	371.537	364.194	313.936	296.324	286.608	158.918	145.551	147.288	167.653	228.650	229.922	253.863
1953	262.435	278.689	294.757	325.195	325.209	328.227	329.359	329.135	328.013	330.139	329.602	330.346	315.925
1954	328.915	326.000	323.687	319.079	319.471	327.113	352.986	548.714	426.870	322.954	319.789	272.224	348.983
1955	224.546	239.650	318.815	317.039	138.588	233.408	235.078	234.928	233.370	420.912	437.325	430.901	288.713
1956	423.118	416.334	407.511	398.091	275.790	238.518	190.001	151.074	192.440	187.477	200.218	220.576	275.095
1957	244.630	250.391	246.891	208.279	131.746	6.000	6.000	31.806	160.618	219.667	234.756	315.193	171.331
1958	313.099	308.916	305.407	302.747	308.527	317.189	321.350	320.570	321.878	322.525	321.547	321.506	315.438
1959	319.124	314.901	311.247	305.708	306.986	455.685	543.760	536.445	529.150	483.217	306.493	306.516	393.269
1960	303.078	299.581	295.058	227.300	236.748	414.508	724.794	670.928	645.377	478.841	328.638	300.127	410.414
1961	242.154	322.663	319.694	317.783	322.615	316.346	232.418	234.784	283.065	300.693	331.594	398.499	301.859
1962	428.509	436.362	429.689	421.698	367.151	341.880	354.460	420.168	414.394	381.478	350.836	386.246	394.406
1963	423.301	472.738	460.307	448.295	287.529	296.592	235.961	251.159	309.389	343.961	402.197	405.542	361.414
1964	440.646	436.677	469.070	438.203	361.425	229.606	259.613	316.848	450.417	422.362	421.383	420.413	388.888
1965	416.194	445.043	446.865	437.292	308.300	303.469	308.419	310.149	309.699	307.606	307.855	306.757	350.637
1966	365.674	379.060	435.961	383.437	356.349	314.978	274.751	276.644	276.613	366.197	313.148	323.054	338.822
1967	419.953	422.086	414.278	405.383	331.519	280.033	298.109	267.281	230.411	311.853	451.606	468.907	358.451
1968	538.141	574.824	546.185	524.611	440.717	416.526	392.658	418.534	400.849	417.238	433.445	490.454	466.181
1969	527.717	502.850	480.568	459.101	345.402	328.460	345.325	375.520	334.144	296.526	369.871	415.443	400.077
1970	468.327	465.432	473.261	466.186	413.390	309.580	57.646	6.000	6.000	32.954	77.005	163.724	244.959
1971	172.548	37.323	38.944	40.451	44.069	52.649	427.860	545.103	419.757	366.297	384.000	455.792	248.733
1972	494.637	507.792	507.902	506.639	354.718	339.448	347.789	348.604	349.916	347.790	364.408	451.400	410.086
1973	501.746	512.248	540.243	525.037	418.853	216.513	181.589	184.734	184.208	183.965	186.637	187.125	318.575
1974	214.339	279.434	348.425	386.888	241.118	403.108	269.710	315.586	365.357	232.783	234.230	236.375	293.946
1975	294.721	399.827	415.115	496.297	471.887	359.301	372.452	464.517	458.223	359.496	230.328	308.780	385.911
1976	398.014	412.406	431.618	335.244	285.762	281.659	233.989	338.565	693.349	656.355	460.402	459.816	415.598
1977	517.579	550.933	537.588	467.031	387.810	762.867	904.387	891.584	570.757	451.730	452.150	499.033	582.786
1978	575.635	560.039	514.555	480.932	410.265	309.506	223.222	230.001	426.313	567.723	458.570	456.050	434.400
1979	488.116	524.003	511.375	497.788	485.871	307.973	171.647	154.683	254.255	343.510	342.890	414.668	374.731
1980	445.369	507.597	515.417	461.823	340.746	422.988	430.948	473.258	417.262	410.001	408.169	472.676	442.187
1981	467.356	454.885	442.128	389.765	292.920	225.395	214.095	287.146	393.179	443.964	456.830	440.801	375.705
1982	423.000	401.000	344.000	264.000	132.000	23.000	6.000	42.000	84.000	182.000	378.000	457.000	228.000
MEANS	365.434	370.969	369.029	349.507	309.913	329.089	347.669	357.165	366.232	344.697	341.797	357.497	350.749

TABLE B2-2

OUTFLOWS FROM WHITESAND DAM (adjusted by Crippen Acres, m^3/s)

CHURCHILL RIVER ABOVE OTTER RAPIDS - STATION NO. 06CD002

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1963	---	---	---	---	---	---	---	---	---	315	265	223	---	1963
1964	183	167	164	163	240	308	252	225	264	349	351	290	247	1964
1965	245	215	197	192	327	438	467	484	491	495	463	417	370	1965
1966	308	328	301	280	297	353	380	346	298	269	247	226	310	1966
1967	210	200	192	183	211	344	398	398	333	252	206	178	259	1967
1968	163	145	132	129	150	169	172	149	139	137	145	148	148	1968
1969	147	145	133	147	234	239	210	209	191	236	232	204	194	1969
1970	183	165	155	147	205	265	535	522	537	486	470	461	346	1970
1971	382	340	309	316	356	381	430	454	394	330	292	265	354	1971
1972	240	228	208	202	369	446	380	329	283	308	313	276	299	1972
1973	232	209	196	191	246	353	484	543	493	469	483	513	369	1973
1974	444	400	370	370	622	790	864	883	761	689	604	554	614	1974
1975	520	421	368	349	412	460	493	505	495	476	484	425	448	1975
1976	363	275	275	280	390	295	446	532	474	428	395	345	367	1976
1977	288	256	234	238	327	428	411	381	341	321	310	266	317	1977
1978	233	218	197	189	324	501	469	377	356	374	362	321	327	1978
1979	278	244	227	221	279	428	449	405	380	386	388	361	338	1979
1980	309	271	247	236	258	230	214	211	226	282	302	272	255	1980
1981	228	206	196	206	265	296	257	211	169	168	134	128	203	1981
1982	111	106	93.3	98.4	171	298	301	296	273	225	194	171	195	1982
MEAN	271	239	221	218	294	370	401	393	363	349	330	302	314	MEAN

LOCATION - LAT 55 38 47 N DRAINAGE AREA, 119 000 km²
LONG 104 44 05 W NATURAL FLOW

CHURCHILL RIVER ABOVE OTTER RAPIDS - STATION NO. 06CD002

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m^3/s)	MAXIMUM DAILY DISCHARGE (m^3/s)	MINIMUM DAILY DISCHARGE (m^3/s)	TOTAL DISCHARGE (dam^3)	YEAR
1963	---	---	---	---	1963
1964	---	368 ON OCT 29	160 E ON APR 23	7 800 000	1964
1965	---	498E ON OCT 9	187 ON MAR 26	11 700 000	1965
1966	462 AT 01:00 CST ON JAN 1	439 ON JAN 1	214 ON DEC 31	9 790 000	1966
1967	---	419 ON JUL 24	171 E ON DEC 27	8 180 000	1967
1968	181 AT 15:30 CST ON JUL 14	180 ON JUL 14	122 E ON APR 10	4 680 000	1968
1969	251 AT 01:30 CST ON OCT 27	251 ON OCT 26	131 ON MAR 27	6 120 000	1969
1970	578 AT 17:26 CST ON JUL 15	578 ON JUL 15	144 ON APR 12	10 900 000	1970
1971	473 AT 15:40 CST ON JUL 26	470 ON JUL 26	257 ON DEC 30	11 200 000	1971
1972	467 AT 00:04 CST ON JUN 5	464 ON JUN 1	195 ON APR 2	9 460 000	1972
1973	564 AT 10:54 CST ON AUG 4	561 ON AUG 3	187 ON APR 9	11 600 000	1973
1974	932 AT 21:50 CST ON JUL 30 *	926 ON JUL 26 *	351 ON MAR 29	19 400 000	1974
1975	561 AT 01:13 CST ON JAN 7	558 ON JAN 1	240 ON APR 3	14 100 000	1975
1976	589 AT 00:12 CST ON JUL 29	589 ON JUL 28	246 E ON FEB 24	11 600 000	1976
1977	442 AT 09:07 CST ON JUN 10	439 ON JUN 9	221 ON APR 12	10 000 000	1977
1978	524 AT 23:24 CST ON JUN 30	521 ON JUL 1	181 E ON APR 10	10 300 000	1978
1979	459 AT 11:41 CST ON JUL 13	457 ON JUL 15	214 ON APR 6	10 700 000	1979
1980	330 AT 00:01 CST ON JAN 1	328 ON JAN 1	206 ON AUG 6	8 060 000	1980
1981	---	303A ON JUN 2	123 ON DEC 29	6 410 000	1981
1982	324 AT 17:38 CST ON JUN 23	323 ON JUN 23	88.5B ON APR 2 *	6 160 000	1982
				9 900 000	MEAN

A - MANUAL GAUGE (SEE REFERENCE INDEX)
B - ICE CONDITIONS
E - ESTIMATED
* - EXTREME RECORDED FOR THE PERIOD OF RECORD

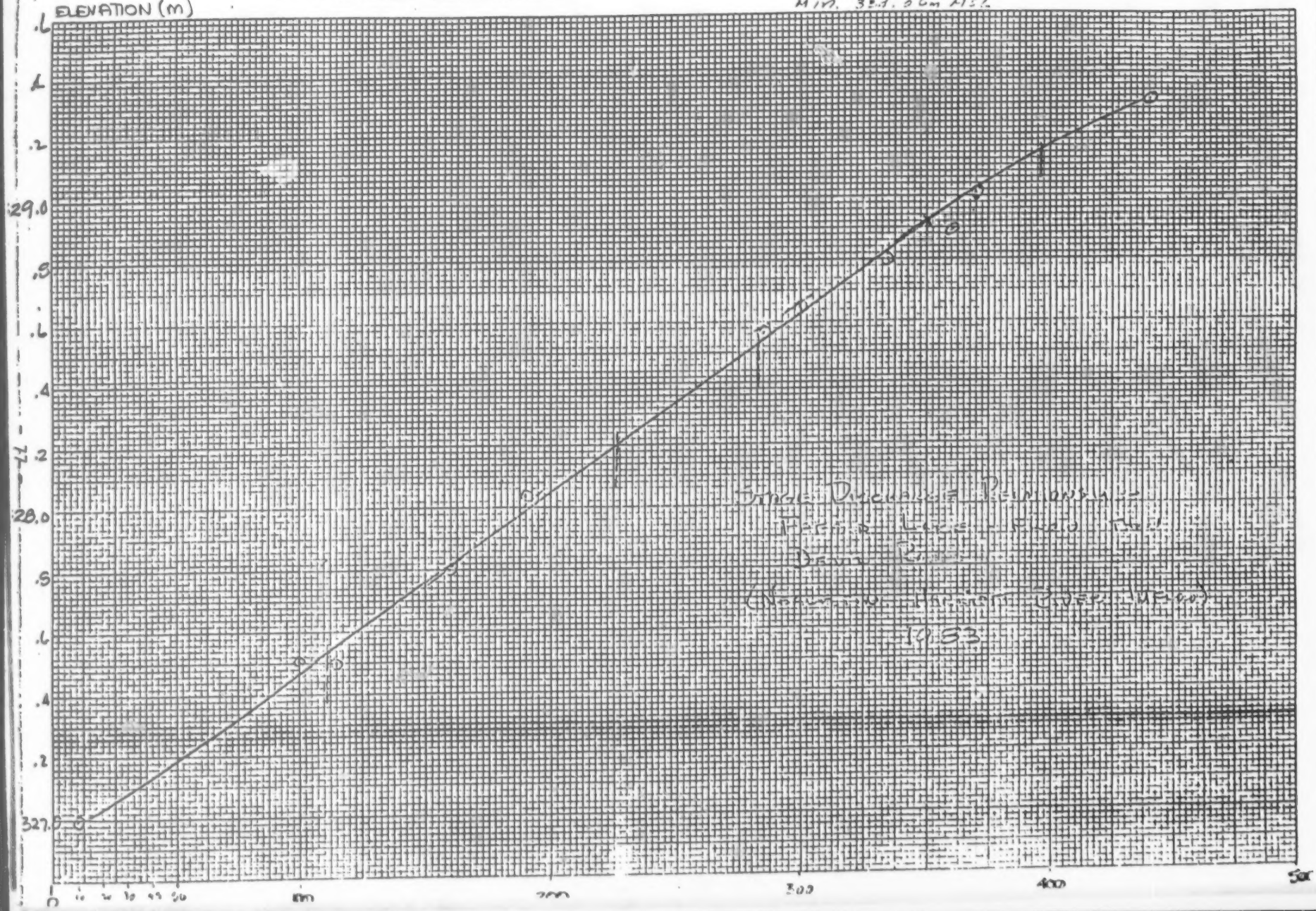
From "Historical Streamflow Summary, Saskatchewan" Water Survey of Canada, 1983

NO. 340R-10½ DIETZGEN GRAPH PAPER
10 X ER INCH

DIETZGEN CORPORATION
MADE IN U.S.A.

STAGE - DISCHARGE FOR FARARD LAKE
FLOW THROUGH DENIL RAPIDS

Max. 336.68m A.S.L
Min. 334.06m M.S.L



APPENDIX D - COST ESTIMATES

COST ESTIMATE FOR OTTER RAPIDS HYDRO-ELECTRIC DEVELOPMENT

Total Estimated Cost

$18,970,000 for initial 2 X 750 MW installation

$10,020,000 for 3 X 1000 kW addition

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
100	Access to Site					
110.1	Permanent access roads		Rm	1.0	235 000	235 000
110.2	Temporary construction roads		km	5.0	200 000	1 000 000
200	River Diversion					
260.1	Supply, place and remove impervious fill		m^3	18 000	10.00	180 000
260.2	Supply, place and remove riprap		m^3	2000	12.00	24 000
290.1	Dewatering		L.S.			5 000
300	Reservoir					
310.1	Reservoir clearing		ha	650	3 500	2 275 000
320.1	Excavation in rock		m^3	500	16.50	8 000
320.2	Excavation in earth		m^3	2000	6.50	13 000
320.3	Supply and place concrete for overflow spillway		m^3	4500	350.00	1 575 000
320.4	Supply and place concrete for gravity dam		m^3	1600	350.00	560 000

REMARKS: This development includes the intakes and part of powerhouse substructure for the 3x1000 kW addition

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Other Rapids Development – initial 2x750kW installation

Fennell, Cochrane, Lavalin

DATE: Sept. 1984 CONTRACT: [illegible] PAGE 1

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
400	Power Plant					
420.1	Supply and place concrete for intakes		m^3	1150	500.00	575 000
470.1	Supply and place concrete powerhouse substructure					
	- for 1500 kW installation		m^3	200	525.00	105 000
	- for 3000 kW installation		m^3	150	550.00	83 000
470.2	Embedded piping, conduit, etc.		L.S.			10 000
480.1	Supply and place concrete powerhouse walls		m^3	45	600.00	27 000
480.2	Supply and erect powerhouse roof		m^3	90	50.00	5 000
480.3	Doors, windows, louvres, etc.		L.S.			20 000
490.1	Excavate tailrace channel in rock		m^3	1500	16.50	25 000
500	Electrical and Mechanical Equipment					
510.1	Supply and install variable pitch, 750 kW tube turbine c/w draft tube, governor, generator, control and protection.		no.	2	520 000	1 040 000
510.2	Supply and install butterfly shut-off valve (ϕ - 2000 mm)		no.	2	50 000.00	100 000
520.1	Supply and install stoplogs for draft tubes		tonne	3.2	3 200.00	10 000
520.2	Supply and install embedded parts for draft-tube stoplogs		tonne	0.8	5300.00	4 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Other Rapids Development - initial 3 x 750 kW installation

Fennell, Cochrane, Lavalin

DATE: Sept. 1984 CONTRACT: 7[illegible]85 PAGE 2

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
520.3	Supply and install monorail hoist for stoplogs		L.S.			12 000
560.1	Supply and install stoplogs for intakes		tonne	4.6	3 200.00	15 000
560.2	Supply and install embedded parts for stoplogs		tonne	1.4	5 300.00	7 000
560.3	Supply and install stoplog lifter		L.S.			90 000
560.4	Supply and install trashracks		tonne	2.1	1 700.00	4 000
560.5	Supply and install embedded parts for trashracks		tonne	0.6	5 300.00	3 000
570.1	Supply and install powerhouse mechanical and electrical service equipment.		L.S.			350 000
580.1	Supply and install transformers and switchyard equipment		L.S.			100 000
	Sub-total					8 460 000
	Allowance for unmeasured items (30%)					2 538 000
	Total for civil mechanical and electrical works					10 998 000
	Indirect Construction Costs (45%)					4 949 000
	COST OF CONSTRUCTION					15 947 000
	Geotechnical site investigation					50 000
	Engineering design and supervision of construction					1 900 000
	Interest during construction (based on 12% per annum)					1 074 000
	TOTAL COST OF PROJECT					18 971 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Otter Rapids Development - initial 2x 750 kW installation

Fennell, Cochrane, Lavalin

DATE: Sept. 1984 CONTRACT: 85 PAGE 3

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
	Addition of 3000 kW at later date					
100	Access to Site					
100.1	Temporary construction roads		Km	5.0	200 000	1 000 000
400	Powerplant					
470.1	Dewater and clean up powerhouse substructure		L.S.			5 000
470.2	Supply and place concrete powerhouse substructure		m^3	300	450.00	135 000
470.3	Embedded piping, conduit, etc.		L.S.			15 000
480.1	Supply and place concrete powerhouse walls		m^3	80	600.00	48 000
480.2	Supply and erect powerhouse roof		m^2	200	50.00	10 000
480.3	Doors, louvres, windows, etc.		L.S.			30 000
500	Electrical and Mechanical Equipment					
510.1	Supply and install variable pitch 1000 kW tube turbine c/w draft tube, governor, generator, control and protection		no.	3	700 000	a 100 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Otter Rapids Development - 3x1000 kW addition

Fennell, Cochrane, Lavalin

DATE: Sept. 1984 CONTRACT: [illegible] PAGE 4

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
510.2	Supply and install butterfly shut-off valve (ϕ = 2300mm)		no.	3	70 000.00	210 000
520.1	Supply and install stoplogs for draft tubes		tonne	6.6	3200.00	21 000
520.2	Supply and install monorail for stoplog hoist		L.S.			8 000
570.1	Supply and install powerhouse mechanical and electrical equipment		L.S.			700 000
580.1	Supply and install transformer and switchyard equipment		L.S.			200 000
	Sub-total					4 482 000
	Allowance for unassessed items (30%)					1 345 000
	Total for civil, mechanical and electrical works					5 827 000
	Indirect construction costs (45%)					2 622 000
	COST OF CONSTRUCTION					8 449 000
	Engineering design and supervision of construction					1 000 000
	Interest during construction (based on 12% per annum)					567 000
	TOTAL COST OF PROJECT					10 016 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Other Rapids Development - 3x 1000 kW addition

Fennell, Cochrane, Lavalin

DATE: Sept. 1984 CONTRACT: 1095 PAGE 5

COST ESTIMATE FOR WHITESAND HYDRO-ELECTRIC DEVELOPMENT

Total Estimated Cost

$ 5,440,000 for initial 750 kW installation

$ 7,560,000 for initial 2 X 750 MW installation

$10,920,000 for 3 X 1000 kW addition

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
100	Access to Site					
110.1	Construct winter access road		Km.	22	25 000	550 000
110.2	Maintain access road for TWO seasons		L.S.			50 000
110.3	Construct temporary construction roads		Km.	2	125 000	250 000
400	Power Plant					
420.1	Prepare foundations for intake and underwater connections		L.S.			50 000
420.2	Supply and install structural steelwork for intake		kg	25 000	2.75	69 000
420.3	Supply and install bellmouth intake		kg	5 000	5.90	31 000
440.1	Remove existing tracks for stoplog lifter		L.S.			5 000
440.2	Excavate existing berm		m^3	500	7.50	4 000
440.3	Supply and erect steel penstock		kg	39 500	5.90	233 000
440.4	Supply and place granular fill		m^3	3 000	10.00	30 000
440.5	Supply and place concrete for anchor blocks		m^3	50	400.00	20 000
440.6	Supply and place concrete slab for stoplog lifter tracks		m^3	6	450.00	3 000
440.7	Replace and re-align tracks for stoplog lifter		L.S.			15 000
470.1	Prepare foundations for powerhouse and underwater connections		L.S.			50 000

REMARKS: The intake and penstock are sized for 2x 750kW units.

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Whitesand Development - initial 750kW installation

Fennell, Cochrane, Lavalin

DATE: Dec. 1984 CONTRACT: 70085 PAGE 1

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
470.2	Supply and erect structural steelwork for powerhouse		Kg	35 000	2.75	96 000
470.3	Supply and place concrete corrosion protection for steelwork		m^3	7	650.00	5 000
470.4	Supply and place concrete for retaining wall		m^3	30	650.00	20 000
480.1	Supply and place permanent slab formwork		m^2	200	60.00	12 000
480.2	Supply and place concrete floor slab		m^3	60	450.00	27 000
480.3	Supply and erect insulated steel superstructure		L.S.			850 000
500	Electrical and Mechanical Equipment					
510.1	Supply and install variable pitch 750 kW Turbogen turbine c/w draft tube and governor		no.	1	386 000	386 000
510.2	Supply and install 750 kW asynchronous generator		no.	1	196 000	196 000
510.3	Supply and install 2375 mm ø butterfly shut-off valve		no.	1	70 000	70 000
530.1	Supply and install powerhouse mechanical equipment		L.S.			75 000
530.2	Supply and install monorail track and hoist		L.S.			35 000
550.1	Supply and install vacuum pump for syphon intake		L.S.			3000
550.2	Supply and install intake trashracks		Kg	20 000	4.10	82 000
570.1	Supply and install powerhouse electrical equipment including turbine protection and control		L.S.			61 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Whitesand Development - initial 750kW installation

Fennell, Cochrane, Lavalin

DATE: Dec. 1984 CONTRACT: 70085 PAGE 2

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
580.1	Supply and install switchyard equipment		L.S.			49 000
580.2	Supply and install transformers		NO.	1	18 000	18 000
	Subtotal					2 795 000
	Allowance for unassessed items - civil works (15%)					281 000
	- electrical and mechanical works (5%)					96 000
	Total for civil, mechanical and electrical works					3 122 000
	Indirect construction costs (35%)					1 093 000
	Construct and maintain construction camp					300 000
	Transportation between La Ronge and site					10 000
	COST OF CONSTRUCTION					4 525 000
	Engineering design and supervision of construction					950 000
	Additional studies					63 000
	Interest during construction (based on 12% per annum)					312 000
	TOTAL COST OF PROJECT					5 940 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Whitesand Development - initial 750 kW installation

Fennell, Cochrane, Lavalin

DATE: Dec. 1984 CONTRACT: 70585 PAGE 3

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
100	Access to Site					
110.1	Construct winter access road		km.	22	25 000	550 000
110.2	Maintain access road for two seasons		L.S.			50 000
110.3	Construct temporary construction roads		km.	2	125 000	250 000
400	Power Plant					
430.1	Prepare foundations for intake and underwater connections		L.S.			50 000
430.2	Supply and install structural steelwork for intake		kg.	25 000	2.75	69 000
430.3	Supply and install bellmouth intake		kg.	5 300	5.90	31 000
440.1	Remove existing tracks for stoplog lifter		L.S.			5 000
440.2	Excavate existing berm		m^3	500	7.50	4 000
440.3	Supply and erect steel penstock		kg	39 500	5.90	233 000
440.4	Supply and place granular fill		m^3	3 000	10.00	30 000
440.5	Supply and place concrete for anchor blocks		m^3	50	400.00	20 000
440.6	Supply and place concrete slab for stoplog lifter tracks		m^3	6	950.00	3 000
440.7	Replace and re-align tracks for stoplog lifter		L.S.			15 000
470.1	Prepare foundations for powerhouse and underwater connections		L.S.			70 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Whitesand Development - initial 2x 750 kW installation

Fennell, Cochrane, Lavalin

DATE: Dec. 1984 CONTRACT: 70085 PAGE 4

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
470.2	Supply and erect structural steelwork for powerhouse		kg.	60 000	2.75	165 000
470.3	Supply and place concrete corrosion protection for steelwork		m^3	13	650.00	8 000
470.4	Supply and place concrete for retaining wall		m^3	60	650.00	39 000
480.1	Supply and place permanent slab formwork		m^2	400	60.00	24 000
480.2	Supply and place concrete floor slab		m^3	120	450.00	54 000
480.3	Supply and erect insulated steel superstructure		L.S.			600 000
500	Electrical and Mechanical Equipment					
510.1	Supply and install viable pitch 750 kW Turbogen turbine c/w draft tube and governor		no.	2	322 000	644 000
510.2	Supply and install 750 kW synchronous generator		no.	2	188 000	376 000
510.3	Supply and install ø375 mm ø butterfly valve		no.	2	70 000	140 000
520.1	Supply and install powerhouse mechanical equipment		L.S.			150 000
530.2	Supply and install monorail track and hoist		L.S.			45 000
550.1	Supply and install vacuum pump for syphon intake		L.S.			8 000
550.2	Supply and install intake trashracks		kg.	210 000	4.10	861 000
570.1	Supply and install powerhouse electrical equipment including turbine protection and control		L.S.			132 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Whitesand Development - initial 2x750 kW installation

Fennell, Cochrane, Lavalin

DATE: Dec. 1984 CONTRACT: 70085

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
580.2	Supply and install switchyard equipment		L.S.			78 000
580.2	Supply and install transformers		NO.	2	18 000	36 000
	Subtotal					3 956 000
	Allowance for unmeasured items - civil works (15%)					341 000
	- electrical and mechanical works (5%)					84 000
	Total for civil, electrical and mechanical works					4 381 000
	Indirect construction costs (35%)					1 533 000
	Construct and maintain construction camp					400 000
	Transportation between La Ronge and site					15 000
	COST OF CONSTRUCTION					6 329 000
	Engineering design and supervision of construction					750 000
	Additional studies					53 000
	Interest during construction (based on 12% per annum)					428 000
	TOTAL COST OF PROJECT					7 560 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Whitesand Development - initial 2x 750kW installation

Fennell, Cochrane, Lavalin

DATE: Dec. 1984 CONTRACT: 70085 PAGE 6

	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
	Access to site					
110.1	Temporary construction roads		Km.	2	125 000	250 000
400	Power Plant					
420.1	Preparation of foundations for intake and underwater connections		L.S.			60 000
420.2	Supply and place granular fill		m^3	1000	10.00	10 000
420.3	Supply and erect structural steelwork for intake		kg.	45 000	5.90	266 000
420.4	Supply and install steel bridge		L.S.			70 000
420.5	Supply and install bellmouth intake		kg.	19 500	5.90	56 000
440.1	Rock excavation		m^3	650	30.00	20 000
440.2	Supply and erect steel penstock		kg.	110 000	5.90	649 000
440.3	Supply and place concrete for anchor blocks		m^3	350	400.00	140 000
470.1	Preparation of foundations for powerhouse and underwater connections		L.S.			90 000
470.2	Supply and erect structural steelwork for powerhouse		kg.	80 000	2.75	220 000
470.3	Supply and place concrete corrosion protection for steelwork		m^3	20	450.00	9 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Whitesand Development – 3 x 1000 kW addition

Fennell, Cochrane, Lavalin

DATE: Sept. 1984 CONTRACT: 17785 PAGE 7

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
480.1	Supply and place permanent slab formwork		m^2	595	60.00	36 000
480.2	Supply and place concrete floor slab		m^2	180	450.00	81 000
480.3	Supply and erect insulated steel superstructure		L.S.			900 000
500	Electrical and Mechanical Equipment					
510.1	Supply and install 1000 kW, variable pitch Turbogen turbine c/w draft tube and governor		no.	3	436000	1 308 000
510.2	Supply and install 1000 kW asynchronous generator		no.	3	241000	723 000
530.1	Supply and install powerhouse mechanical equipment		L.S.			270 000
530.2	Supply and install monorail hoist and track		L.S.			55 000
550.1	Supply and install vacuum pump for syphon intake		L.S.			5 000
550.2	Supply and install intake trashracks		kg.	30 000	4.10	123 000
570.1	Supply and install powerhouse electrical equipment including generator protection and control		L.S.			300 000
580.1	Supply and install switchyard equipment		L.S.			145 000
580.2	Supply and install transformer		no.	3	21000	63 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Whitesand Development - 3x1000 kW addition

Fennell, Cochrane, Lavalin

DATE: Sept. 1984 CONTRACT: 70085 PAGE 8

ITEM NO.	DESCRIPTION		UNIT OF MEASURE	QUANTITY	UNIT COST	TOTAL
	Subtotal					5 849 000
	Allowance for unmeasured items - civil works (15%)					929 000
	-electrical and mechanical works (5%)					150 000
	Total for civil, electrical and mechanical works					6928 000
	Indirect construction costs (35%)					2 250 000
	Construct and maintain construction camp		L.S.			500 000
	Transportation between La Ronge and site		L.S.			320 000
	COST OF CONSTRUCTION					9 198 000
	Engineering design and supervision of construction					1 100 000
	Interest during construction (based on 12% per annum)					622 000
	TOTAL COST OF PROJECT					10 920 000

REMARKS:

COST ESTIMATE

PROJECT: Whitesand Hydroelectric Project
Whitesand Development - 3x1000 kW addition

Fennell, Cochrane, Lavalin

APPENDIX E -
DATA SHEET
FOR TURBOGEN TURBINE

Construction Data

TURBOGEN

Gear Driven Turbine

The Bamford Gear Driven Turbine is a bulb turbine with a built-in step-up gear, and consists of four principal parts: the runner and shaft which are the parts which rotate; the guide vanes which are for directing the water into the runner; the discharge cylinder or draught tube which conveys the water to the discharge pit or tail race after it has left the runner; and the step-up gear which is a bevel drive to the generator.

The runner has four blades of nickel aluminium bronze which are pivoted in a bronze hub. The adjusting mechanism consists of a crosshead crank ring and control rod - all also assembled in the hub.

The shaft is a high quality steel forging bored hollow to accommodate the governing control rod and the hydraulic piston. The shaft is also specially coated with chrome oxide in way of the main seal.

The guide vanes (non-adjustable) are a steel pressing of helical design welded into the split runner casing.

The draught tube is a fabricated taper cylinder, specially designed and dimensioned according to the hydraulic aspect to make a major contribution to the transformation of energy.

The step-up gears are helical bevel gears designed and manufactured by a well-know gear manufacturer. The "step-up" speed is to enable a standard generator to be used. The wheel is bolted and dovelled to the main shaft whilst the pinion is integral with the output shaft. They are both manufactured from high quality, high tensile steel, hardened and ground.

The main shaft has two bearings: one a heavy duty split roller bearing designed to withstand the main journal load of the runner and bevel wheel; the other, a thrust bearing, comprising a matched pair of taper roller bearings designed to take the thrust of both runner and bevel drive. Both bearings have an estimated life of 100,000 hours.

The hydraulic power pack consists of gear type oil pump, filter and relief valve. The pump will be either direct driven from the turbine output shaft or electrically driven if a supply is available. The purpose of the power pack is to supply lubrication oil to the gears and bearings and hydraulic power for the governing, the clutch and other shut-down devices such as hydraulic activation of the slide or butterfly valves.

Governing is carried out electrically and consists of three main components: a magnetic pick-up, speed control unit and electric hydraulic servo control valve. The magnetic pick-up senses the turbine speed by producing a voltage caused by a gearwheel passing through its magnetic field. This voltage or signal is fed to the speed control valve activating the necessary signal to the electrical hydraulic servo valve which directs pressure oil to either side of the hydraulic piston via a distributor on the end of the main shaft. This signal, therefore, alters the angle of the runner blades to suit the load demand. A mechanical feed-back is also incorporated into the design.

The generator is driven by the turbine via a hydraulic clutch. This clutch also acts as an over-speed safety device for the generator. If at any time the turbine was to go into overspeed, a signal from the speed control unit would activate a valve, cut-off and drain the hydraulic fluid to the clutch before the speed has reached danger point for the "standard" generator.

The output or pinion shaft also has two bearings - one a heavy duty roller bearing mounted directly behind the pinion and designed to withstand the heavy journal load of the gear; and the other a matched pair of taper roller bearings to withstand the thrust of the bevel pinion. These bearings also have a life of 100,000 hours.

The body of the turbine consists of two casings; the runner casing and the main casing. The runner casing which carries the guide vanes is "split" to enable access to the runner, seal and split roller bearing. The main casing is robustly designed to carry the main shaft and bevel drive. Both casings are steel fabrications suitably ribbed to withstand any hydraulic surge. They are both pressure tested to at least twice the working pressure.

The double split lip seal has been specially designed for turbine application, which can be changed quickly and without disturbing the casing or any other parts. Between the two lips is a "tell tale" hole connected by pipe to the outside of the casing to act as a warning and to drain any water passing the first lip. The seal life is estimated, depending on the installation, to be approximately five years. (For high head, this lip seal would be replaced with Bestobell split hydraulic face seal.)

Lubrication for the bevel wheels is both oil bath and pressure jet, and for the bearings both pressure and splash. The oil being delivered from the hydraulic power pack.

The generator and switchgear is to customer's requirements depending on the installation. The generator itself is a completely standard (not designed for overspeed) unit.

MAINTENANCE: The turbine has been designed for long life operation with minimal maintenance. In the event that access is required, this has been made as easy as possible for in situ repairs or replacement to be made. As mentioned above, the runner casing is of a split design which enables it to be removed easily without disturbing the main casing of the draught tube. This has been achieved by the use of robust seals and withdrawable distance pieces.

On removing the runner casing, the runner itself, the main seal and the split roller bearing can be serviced. Also the pinion shaft assembly can be completely removed.

To obtain access to the main thrust bearing, the main casing will have to be lifted out of situ, but with the runner casing already removed, this operation is straightforward. The main thrust bearing shaft and bevel gear, etc., are then easily accessible.

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